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DEPARTMENT OF MINES

GEOLOGICAL SURVEY

HON. LOUIS CODERRE, MINISTER; A. P. LOW, DEPUTY MINISTER;
R. W. BROCK, DIRECTOR.

MEMOIR No. 25

REPORT

ON

THE CLAY AND SHALE DEPOSITS

OF THE

WESTERN PROVINCES

(PART II)

BY

HEINRICH RIES

AND

JOSEPH KEELE

OTTAWA

GOVERNMENT PRINTING BUREAU

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No. 1279

LETTER OF TRANSMITTAL.

To R. W. Brock, Esq.,
Director Geological Survey,
Department of Mines,
Ottawa.

SIR:—We beg to submit, herewith, Part II of our report on the Clay and Shale Deposits of the Western Provinces.

We have the honour to be,

Sir,

Your obedient servants,

(Signed) **Heinrich Ries.**
Joseph Keele,

June, 1912.

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CLAY AND SHALE DEPOSITS

OF THE

WESTERN PROVINCES.

Part II.

BY

Heinrich Ries and Joseph Keele.

INTRODUCTION

During the field season of 1910, three months were spent in the region between Winnipeg and the coast, making a reconnaissance of the formations which were likely to yield clay or shale deposits that might be of value in the ceramic arts.

The results of this work, published as Memoir 24-E, indicated that there were not only extensive clay and shale formations in the region covered by this report, but that some of them at least were of excellent quality and adapted to a variety of uses.

The summer of 1911 was spent by us in the same general territory investigating areas which we did not have time to visit the previous summer and also following out several new lines of railway which were in course of construction.

The several transcontinental lines are rapidly sending out new branches, or extending old ones, and as this is done new areas of clay or shale become accessible. Of special importance in this connexion will be the line of the Canadian Northern railway extending southward from Moosejaw, and the Canadian Pacific Railway branch from Moosejaw to Lethbridge. Both of these will pass near either the Dirt hills or the Cactus hills, which contain splendid clay deposits. A line from Estevan to Lethbridge would also probably pass through good clay country.

In our first report on the western provinces, the region was subdivided first geographically, and second on a formational basis, for convenience of discussion.

The same plan is maintained in the present report, with the additional object of greater convenience of comparison.

While this year's work has not developed the existence of new clay types, still it is important because it shows the extension of several useful types discussed in our previous paper, and also because the work of a year has served to verify many of the predictions or statements made in our previous contribution.

We believe that we are safe in saying that the first season's work on the clays of the western provinces has served to greatly stimulate interest in them, and has been directly or indirectly responsible for the establishment of some new plants for the manufacture of clay products.

This is, of course, gratifying, for there seems to us no good reason why many of the burned-clay wares now being imported from the United States for consumption in the growing cities and towns of the Great Plains and Pacific Coast region, should not be of domestic manufacture

As in the previous year, we collected a number of samples for laboratory tests, the results of which are included in the body of the report, and also summarized in tabulated form at the end of it.

A feature of the laboratory work this year was the performance of a special series of tests on certain promising clays in order to determine their value for the manufacture of sewer-pipe and roofing-tile. Some of these yielded most encouraging results. Mr Keele also made a somewhat detailed investigation of the preheating treatment as applied to the clay of western Canada.

CHAPTER I.

Great Plains Region.

Surface Clays.

By far the greater number of clay deposits worked in the Great Plains region are surface clays of unconsolidated character and recent geological age.

This will probably continue to be the case, if a local industry is built up at many points, for the reason that in many parts of the Great Plains area the older shales are so deeply buried as to be inaccessible

The fact should be borne in mind,however,that these surface deposits may vary in their character from place to place, the phases seen including silts, clays, gravel, and sand. Of these the silty type is perhaps the most abundant.

On a basis of their origin we divided them into (1) lake clays, (2) river-terrace or flood-plain deposits, (3) delta deposits. The differences between these were pointed out in last years' report and need not be repeated here.

For common brick many of these surface silts, or silty clays work well, provided they are properly handled.

Knowing that the deposits may vary from point to point, within a short distance, the ground should be carefully looked over before the location of a plant is decided on, and then the deposit selected should be tested before a plant is erected, for nothing is more costly than experimenting with a fully built and completely equipped plant.

Surface clays will usually be chosen in preference to shale for common-brick manufacture because they are easier to dig and work. They do not always give the better results, however, when a comparison of these two classes of material is made

But around some of the larger cities of the Plains the surface clays must be drawn upon for a local source of supply

Some of the localities not mentioned in last year's report are referred to below

Regina, Sask. Regina, the capital city of Saskatchewan, is one of the rapidly growing communities of the Great Plains region, and with this development there is a corresponding demand for bricks, drain tile, sewer-pipe, and other burned-clay wares.

There are no shale deposits available in the immediate vicinity of the city, as the thickness of surface clay which underlies the vast plain surrounding the city is astonishingly great. In fact borings made by the city authorities in an endeavour to obtain a deep water supply, have proven not less than 2,200 feet on unconsolidated beds

A good opportunity to observe the character of the materials lying immediately under the surface was afforded in the summer of 1911 by the excavation of a deep trench for the trunk sewer The section exposed there showed —

Dark-coloured loamy clay	4 feet
Stiff, dark clay, vertically jointed	15 "
Yellowish silty clay	2-6 "
Stiff, dark clay, like second layer	

The jointed clay forms the greater part of the deposit, but no successful attempts have been made to utilize it for brick making purposes.

It forms a stiff, sticky mass when tempered with water, is hard to work, and cracks in drying. It could probably be made available for brickmaking, if treated by the preheating method but it is doubtful if such a low-grade clay could be handled commercially under these conditions.

The yellow silty clay, which is slightly calcareous, seemed to promise better results, and a small sample (1809) was taken for testing with the following results.

It moulded up with 27 per cent of water to a smooth mass of good plasticity Its average air shrinkage was 8 6 per cent, and it burned to a red colour.

At cone 010 the fire shrinkage was 0.4 per cent and absorption 15.2 per cent. At cone 05 the fire shrinkage had increased to 1.0 per cent, with an absorption of 12.4 per cent. At cone 03 the fire shrinkage was 2.7 per cent and the absorption 5.9 per cent. The clay fused at cone 1. It will be seen from these tests that it does not stand a very high degree of heat, and is classed as a brick clay, but it might also work for drain tile.

If this clay could be found near the surface in some of the small stream valleys in the neighbourhood, and of sufficient thickness, it would well repay working for common brick.

All the structural materials used in Regina are brought in from some distance, none being produced there. A good deal of concrete construction is used, and the gravel for this purpose is brought from a high terrace on the north side of the Qu'Appelle valley at Lumsden.

Saskatoon, Sask.—The brickyard at this locality is owned and operated by Messrs. Elliott and Slack. The deposit worked for brickmaking (Plate I) consists mostly of silty clay containing lenses of sand, and irregular bodies of stiff glacial clay, overlying boulder clay. Scattered through the deposit are streaks and pockets of black clay resembling weathered shale, which are very difficult to work, and particles of it behave as pebbles in the burned brick. The whole deposit is worked, the silty clay portion being used without admixture, but a quantity of the sand is mixed in with the stiff clay.

The drying racks are provided with canvas screens to protect the green bricks from cracking during the early stages of drying (Plate II). 24,000 soft mud bricks a day are produced throughout the season, all going to supply a local demand. The water-smoking and burning in scove kilns is completed in a comparatively short time at this yard, only five days being taken for this operation. Considering the unpromising nature of the materials used, a fairly good red brick is produced, and the hard burned ones have a good ring.

A small sample of the clay (1802) as it went into the machine was taken for testing.

The tests showed that while the clay was exceedingly gritty it worked up to a rather plastic mass with 25 per cent

water It is non-calcareous in character The air shrinkage, 8 per cent, is rather high for such a gritty material.

The burning tests showed that it burns to a light-red body, except at cone 1, at which point it becomes brown.

At cone 010 the fire shrinkage was 1 per cent and absorption was 15 7 per cent. At cone 05, these were 1 7 and 14·3 per cent respectively At cone 1 they were 4 7 and 1·9.

The clay should make a good common brick, but is not to be recommended for anything else

Wetaskiwin, Alta —A small plant for the manufacture of stiff-mud bricks commenced operations in the season of 1911 at Wetaskiwin, Alta. The material used at these works is a surface clay, about 14 feet in thickness, overlying boulder clay and gravels. The upper 4 feet of the deposit is a rather sandy clay loam, the under portion being a stiff stratified clay. The upper part alone is used for brickmaking, as the under clay is too hard to work, and cracks while drying. The under clay could probably be worked if sufficient sand were added, but there does not appear to be any sand available in this neighbourhood. No bricks had been burned at this yard at the time of our visit.

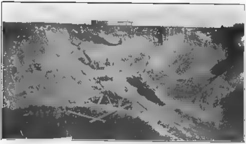
Borings made for gas and water at Wetaskiwin passed through the following measures —

Soil and sand	10 feet.
Blue clay ..	82 "
Sandstone	1 "
Blue shale.	27 "
Alternating sandstones and shales	285 "
Coal	8 "
Alternating sandstones and shales	531 "
	944 "

A light flow of 25 pounds pressure of natural gas is obtained at the above depth. This is used to supplement the supply made from a gas producer, which operates the pumping, electric light, and power plants.

A good flow of water of excellent quality is obtained from thick beds of sandy shales and sandstones at a depth of 200 feet.

PLATE I



Clay pit at brick works Saskatoon, Sask

PLATE II

Brickyard at Saskatoon, Sask. Shows drying racks covered with canvas screens, to prevent too rapid drying and consequent cracking of the bricks

Camrose, Alta.—A small plant making stiff-mud brick from glacial clay is operated intermittently at Camrose, Alta. The clay is faintly stratified and carries scattered pebbles so irregularly distributed that many portions of the deposit cannot be worked, although certain parts of the clay which are fairly free from them can be utilized. During the last attempt to work this deposit, too many pebbles were allowed to pass into the bricks and the result of this was disastrous.

Wainwright, Alta.—A small quantity of common brick was made during the summer of 1910, at this town. The deposit worked consisted of silt and sand, with a few pockets of clay. The bricks when burned were too weak and porous to be of any value, as the sand content was too great, and the site was abandoned. Messrs. Taylor and Clark began making stiff-mud bricks during the season of 1911. The deposit, situated a short distance west of the abandoned site is glacial drift consisting of irregular masses of silty clay, sand, and gravel, with some minor pockets of stiff clay. These clay pockets are so scattered through the other drift materials that a large area will have to be worked over to assemble sufficient clay to keep a brick plant in operation constantly throughout the season. No burning had been done in large kilns in this yard at the time of our visit, but some bricks burned on the ground in a small test kiln were hard and of a good red colour.

A casual examination along the line of the Grand Trunk Pacific railway shows a lack of brick clays for a considerable distance both east and west of Wainwright. This line for the greater part of its course between Saskatoon and Edmonton, traverses a region covered with a thick sheet of glacial drift, consisting of sand, gravel, and boulder clay. The monotonous succession of ridges and mounds, with small shallow depressions, many of which contain water, are characteristic of glacial topography.

Some small samples of surface clay were collected in the northern part of the Province of Saskatchewan by Wm. McInnes, of the Geological Survey, during his explorations in that region, and were tested by J. Keele,.

One of these (1832) was a gritty non-calcareous clay from the valley of the Wuskatasko river, a tributary of Grassy

river It worked up with 22 per cent of water to a rather plastic mass having an air shrinkage of 5 per cent. It burned to a light-red brick at cone 010, with 0 7 per cent fire shrinkage and 20 per cent absorption, the body being almost steel hard. At cone 03 the bricklets were vitrified, with a fire shrinkage of 11 per cent. The clay was completely fused at cone 1 The material makes a good common brick.

A second sample (1833) is a calcareous surface clay from Wuskwatim lake This one developed only medium plasticity when mixed with water, and had an air shrinkage of 5 6 per cent It burned to a light-red porous body at cone 010, with a fire shrinkage of 1 per cent, but the absorption was high, being 24 8 per cent. At cone 03 the body was vitrified, and the fire shrinkage of 12 per cent was high This clay fused at cone 1

It should make fairly good common brick, but needs to be burned somewhat higher than cone 010.

Both samples of clay were taken from shallow pits not more than a foot below the surface, and the amount collected was too small for a complete test.

A large sample of surface clay from the Pas, Saskatchewan river, was submitted by John Armstrong, C E. The material was collected from the trenches made to receive the abutment for the Hudson Bay railway This was a highly calcareous glacial clay, containing numerous limestone or dolomite pebbles. The clay burned to a buff-coloured, porous, weak brick at all cones up to cone 3, and is useless for the manufacture of structural wares

Weyburn, Sask.—This town lies on the Moosejaw-Portal branch of the Canadian Pacific railway, and is surrounded by rolling prairie country, whose surface material is all of Pleistocene age. It consists of clay loams, sand, and boulder drift.

In the autumn of 1910 a brick yard was started by Hunt, Bunting, and West, about three-fourths of a mile northwest of Weyburn, and along the railway track. The material used was a loamy clay lying immediately below the surface. This brownish

clay extended to a depth of about 6 feet, and was underlain by a thin bed of gravel, and this in turn by gumbo.

The deposit is typical of many that may be found in this part of the Plains region.

At the time of our visit the plant was still in an experimental stage.

It was equipped with a dry pan, inclined stationary screen, and a 4 mould dry-press. There were three circular kilns 30 feet in diameter, and the Boss system of forced draft was used. The fuel employed was lignite from Bienfait.

No tests were made of the clay, but it burns to a reddish colour.

Edmonton, Alta. Attention was called in last year's report to the extensive use of flood-plain clays for common and pressed brick at this locality.

We also described two unworked deposits, which appeared to us to be of better grade, that is more plastic, than the flood-plain clays that were in use. Tests of these were given.

Reference was also made to a clay deposit being worked 7 miles north of Edmonton, which we did not have time to visit in 1910 but did in 1911

This is the plant of the Acme Brick Company (Plates III, IV) located along the line of the Canadian Northern railway.

The deposit here (Plate V) presents a somewhat different section from elsewhere.

The upper clay is laminated and tough, while under this there is a very sandy clay from 12 to 15 feet thick. This sandy clay, which is dense and hard to break down, contains some streaks with gypsum rosettes.

The top clay if used alone cracks, and consequently the Company employs a mixture of one-half top clay, and one-half lower sand.

The clay is hoisted up an incline to the yard, where it is put through a rolls and pug mill, and then moulded in a Freese combination machine.

Part of the bricks are dried by artificial heat, and the overflow is hacked up in sheds. Up to the present time the

Company had been using scove kilns, but they had just completed one rectangular kiln which was to be fired by the Bose system of forced draught.

Laboratory tests of the yellow clay (1764) showed it to be very gritty and of calcareous character.

Nevertheless it worked up to a fairly plastic body, whose average air shrinkage was 7·2 per cent. Only a few burning tests were made of the wet-moulded bricklets, and the results of these are given below.

Cone	Fire shrinkage.	Absorption.	Colour.
010	0·4	22·0	Light red.
05	0·6	19·4	Red.
03	1·3	11·7	"
3	10·6	Vitrified.	Brown.
5	Fused		

These tests indicate that the clay burns to a good red body, although a somewhat absorbent one at cone 010, and the shrinkage is still low at cone 03, with a considerable drop in the absorption. It makes a good common brick by the soft mud process, but it is doubtful if the material could be used for fireproofing and drain tile.

It is interesting to compare this clay with two collected last year one of these (1659) from terrace near the University of Alberta, and the other (1655) from 4 miles northeast of Edmonton.

Its (1764) air shrinkage is a little lower than the other two. It burns less dense at cone 010 than the other two, but has about the same fusing point.

Bassano, Alta.—The Bow river makes a large bend south of here which is known as the Horseshoe Curve. The banks are about 90 feet in height, and show nothing but boulders, clay, and silt.

In drilling a well for gas at Bassano, the shales were struck at a depth of about 125 feet.

Plate III

Plant of the Acme Brick Company [illegible] miles north of Edmonton, Alta

Plate IV

Setting green bricks in scove kiln Acme brick works. Edmonton, Alta

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CHAPTER II.

Shale Formations.

CRETACEOUS SHALES.

Shales of Cretaceous age and lower than the Laramie, which cannot be classed as wholly Cretaceous, are worked only in Manitoba.

In that Province they extend from the Pembina river at the International Boundary northwestward along the base of the Pembina, Riding, Duck, and Porcupine mountains.

In Manitoba this system contains in ascending order the Dakota, Benton, Niobrara, and Pierre.

The general relationships and characteristics of these were discussed in Memoir 24-E.

PIERRE AND NIOBRARA.

There is a marked difference between the shales of these two formations, as last year's tests showed.

The Pierre shales weather but slowly, the main change being a disintegration of the shale deposit into a number of scaly fragments. Even these when ground up and mixed with water do not yield high plasticity, nor do they burn readily to a dense body. They are, however sometimes more refractory than most of the shales of the Great Plains area, showing a fusing point of as much as cone 15.

The Niobrara shales on the other hand are decidedly more plastic, denser burning, and with a much higher shrinkage, and tensile strength. They also burn to a better colour, but are sometimes gypsiferous, so that after burning the gypsum unless well broken up may show itself as white specks. On the other hand the Niobrara shales do not stand as much heat as the Pierre shales, and may at times develop black coring if not burned slowly.

As a result of some tests which were made, the suggestion is advanced that it would be desirable to use a mixture of Pierre and Niobrara shales at some of the localities where these two could be found close together.

A number of tests of Pierre shale, and one of Niobrara shale were given in last year's report. Of all those mentioned the only one being worked was that at Leary. None of the Pierre shales tested were being utilized. Indeed the Pierre shale has been manufactured into brick at only one locality, viz., LaRivière, Man., and this is described below.

Both the Pierre and Niobrara have been uncovered farther westward in Saskatchewan, in excavations for new lines of railway.

These several localities are next described.

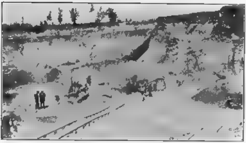
LaRivière, Manitoba. —This town is situated on a railway, about 84 miles southwest of Winnipeg, Manitoba. The town itself lies in a small valley surrounded by low hills, the slopes of many of which show outcrops of the Pierre shale, and it is quite evident from the numerous outcrops around the town and those in the railway cuttings to the east of the town that there is a very large quantity of this material available. The plant of the Phoenix Pressed Brick Co. is located on the edge of the town at the base of one of these shale escarpments (Plate VI).

The bank of shale is about 70 feet in height, and the material extends in a practically unweathered condition right up to the grass roots.

It shows the usual characteristics of the shale found in this formation. That is to say, it is hard, does not mellow down very easily, and grinds up with the same difficulty that was experienced with other samples of this rock that were tested by us in connexion with last year's work.

The entire thickness of the shale bank is not worked, most of the material for the factory being taken from the upper 30 feet of the deposit, and while there does not seem to be very much difference in the appearance of the different parts of the bed, still the brick manufacturer divides the bank into several benches.

PLATE V



Clay pit of Acme Brick Company, north of Edmonton, Alta.

PLATE VI

Bank of Pierre shale, La Rivière, Man.

The upper 30 feet is called the top bench. The next 30 feet, spoken of as the second bench, is said to burn slightly browner than the overlying material. Near the base of the bank is a 4 foot layer of shale, which was claimed to be refractory.

The material from the upper bench (1745), is a somewhat hard shale, which does not weather down easily, and after grinding and mixing with 33 per cent of water, gave a mass which was only feebly plastic, and difficult to mould. The average air shrinkage was 4·8 per cent, but the tensile strength was very low. It seems so short that it is doubtful whether it could be moulded by any plastic process.

By taking care, some wet moulded bricks were made from it, and these gave the following results on firing.

Cone.	Fire shrinkage.	Absorption	Colour
	%	%	
010	2·3	27·7	Light red.
05	5·4	2[illegible]	"
03	6·0	20·4	"
1	6·0	19·4	"
5	6·6	16·8	Red.
9	8·6	13·4	Dark red.
15	Nearly fused		

These tests show the shale to have the usual characteristics of the Pierre shales. At the temperatures commonly reached in brickmaking, the shrinkage is not excessive, but the absorption is altogether too high. The clay is barely steel hard even at cone 9.

A dry-press bricklet burned to a light-red colour, and at cone 03 had a fire shrinkage of 6 per cent, with an absorption of 23·4 per cent. At cone 1 the fire shrinkage was 7·5 per cent, and the absorption 18·5 per cent. The colour had deepened, but the clay was not steel hard.

It is probable that the dry-press process is the only one to use with this clay, even though it gives a very porous brick.

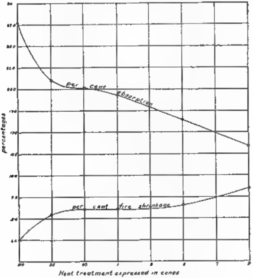


FIG. 1.—Absorption and fire shrinkage curves of shale from LaRivière. Man.

The shale from the second bench (1746) is more thinly laminated than the preceding, but does not weather down any more readily. Like other samples of the Pierre shale it took a high percentage of water to work it up, and gave but a feebly plastic mass, which, however, was considerably more plastic than the preceding, and yet, although absorbing this high amount of water its air shrinkage was not excessive, being 5 per cent. The average tensile strength was not high, viz., 51 pounds per square inch.

In burning, the wet-moulded bricklets behaved as follows:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	3·0	25·1	Salmon.
06	6·2	20·0	"
03	6·6	19·6	Light red.
3	8·0	13·4	Dark red.
5	8·0	12·0	"
9	Not fused.		
15	Nearly fused.		

This shale shows a slightly higher fire shrinkage than No. 1745, but it is not much lower in its absorption. It is practically steel hard at cone 3, but the colour is not very bright. A dry-press bricklet at cone 03 had a fire shrinkage of 7 per cent, absorption of 23·4 per cent, and light-red colour. Another one burned at cone 1, had 9 per cent fire shrinkage, 18·5 per cent absorption, and dull-red colour. This latter bricklet was nearly steel hard.

The refractoriness of these as compared with some of the other shale formations of the Great Plains is interesting. They are not fireclays, but they do stand a very fair degree of heat, viz., the fusing point of cone 15 which is 2606° F. (1430°C.) Two other Pierre shales, one from Souris (1632) and the other from Assiniboine river (1634) were not fused at cone 15. The so-called fireclay from the bank of the brick works at LaRivière also fused at cone 15.

If this clay is to yield a good hard brick, it should be worked dry-press and well burned. If some local surface clay could be found near by to mix in with it much better results could be obtained, and with such a mixture the shale could probably be used for fireproofing in a stiff-mud machine.

A somewhat continuous attempt has been made to make dry-pressed brick from this shale, and during the operation the plant has undergone several changes. When the plant was visited in June, 1911, the process included the use of a disintegrator, two short pug mills, and a Bradley and Craven semi-plastic machine.

The latter consists of a revolving table similar to that used with the Sword's stiff-mud machine. As the bricks come from the mould they are pushed forward automatically to a one mould re-press. The plant was originally equipped with a 6 mould Boyd re-press, but this is said to have been a failure. The Company also, for some unexplained reason, installed a dryer for the dry-pressed brick.

The burning is being done in circular down-draught kilns.

The shale would probably work very much better if it were mixed with some plastic surface clay to be found in the vicinity. Moreover, owing to the toughness of the raw material, care should be taken to grind it sufficiently fine, as the bricks now being made are quite coarsely granular.

There still remains the possibility of using a mixture of Pierre and Niobrara shales. The Niobrara shale outcrops in the country around Morden, and the Pierre shale extends farther east than LaRivière. The problem, therefore, would be to locate a plant at a point where the two are close together. Since this possibility exists, a mixture (1747) was tried consisting of two parts of Pierre shale from LaRivière and one part of Niobrara shale from Leary. We used the Leary material simply because we had some of it in the laboratory.[1]

This mixture when wet-moulded developed excellent plasticity, and had an air shrinkage of 5 per cent.

The burning tests of the wet-moulded bricklets were as follows:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	1·6	23·8	Salmon.
05	5·0	14·8	"
1	8·0	12·8	Dark red.
3	6·5	10·4	"

It is interesting to compare the results of these tests with those of the Pierre shale alone (See LaRivière 1745 and 1746).

[1] This was a sample collected in the summer of 1910, and described in Memoir 24-E.

The addition of the Niobrara shale did not affect the fire shrinkage much, but it brought down the absorption considerably

As this mixture was of good plasticity, a sample of it was run through a 3 inch annular die. The clay flowed smoothly. These pipes were then placed in a large sewer-pipe kiln fired at cone 4, and took a good salt glaze, while the total shrinkage was 11 per cent. If such a mixture were used for sewer-pipe, it might be well to grind it in a wet pan, as this would probably give a smoother surface to the pipe. The mixture is sufficiently refractory to stand salt glazing.

This same mixture, or perhaps one with even less Niobrara shale in it, could, we believe, also be recommended for fireproofing.

Saskatchewan Province.—In the Province of Saskatchewan, the Pierre shales are exposed for several miles in high cliffs on the Brandon-Saskatoon branch of the Canadian Pacific railway.

These are seen shortly after the railway line leaves the prairie level in its descent to the valley of the Qu'Appelle river, by way of Cut Arm creek. The shales first seen are probably the upper part of the Pierre, and are similar in appearance to those at LaRivière and other localities in Manitoba, described in the previous report. The shales lower down in the section toward the bottom of the Qu'Appelle valley appear to differ in quality from those in the upper part, in being denser-burning, and not so refractory, in fact they behave more like the Niobrara shale from Leary, Man.

A small sample of weathered shale (1810) of this character from the valley slope east of Tantallon gave the following results

It is a very plastic, smooth shale which, when mixed up with 33 per cent of water, gave a rather sticky body, that was hard to work, and had a tendency to crack in drying. The air shrinkage of 8·2 per cent is somewhat high for practical working and the clay would give better results if mixed with sand. It burned to a red colour, and gave a brick with a good ring. While the shale behaved somewhat like a Niobrara shale in burning, still it did not show any tendency to develop a black core, which was the case in some other Niobrara samples tested.

At cone 010 it showed no fire shrinkage, an absorption of 14.1 per cent, and was steel hard. At cone 05, the fire shrinkage was 6.3 per cent, and absorption 1.3 per cent.

It will be seen from these tests that it densified quite rapidly. The clay vitrifies at cone 1, and is to be classed as a brick clay.

The shales in the upper part of the valley slopes are hard and non-plastic, but if these were mixed with the softer plastic shale lower down, they would probably give good results, if used for making fireproofing or brick.

The valley bottom also contains some loamy clays and stiff, dark coloured surface clays, which might also serve as plastic ingredients to use with the hard shale.

A bed of bentonite (?) about 7 inches in thickness, occurs overlying the Pierre shale. It was exposed near the residence of Senator Douglas which overlooks the Qu'Appelle valley, a few miles east of Tantallon. This material seems to possess all the properties of the bentonite which occurs in the Edmonton series at Camrose and is described in a later part of this report.

The upland country, particularly to the west of Tantallon, is well wooded, and should yield a good supply of dry poplar fuel for burning clay products.

The Niobrara shales occur along the west shore of Lost Mountain lake (Plate IX), in the Province of Saskatchewan. These shales are exposed in the cuttings of the newly constructed Regina-Bulyea branch of the Canadian Pacific railway.

The first exposure is seen about 4½ miles north of Valeport junction. It consists of dark grey, weathered shale, being very soft and easier to excavate than the boulder clay which overlies it. There is a thickness of 9 feet of shale exposed above the railway track at this point, with an over-burden of 3 feet of glacial drift.

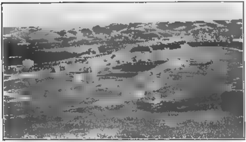
The shale contains small plates of gypsum and numerous ironstone nodules or concretions, but they are mostly large enough to be thrown aside in mining.

A sample of this shale (1803) mixed up with 27 per cent of water to a tough, compact mass that was hard to work when wet, as it was very plastic and sticky, and, moreover, did not stand rapid drying.

PLATE VII

The Qu'Appelle valley at Tantallon, Sask.

PLATE VIII



The Qu'Appelle valley at Lumsden, Sask.
View looking south from gravel pit

The average air shrinkage of 12 per cent was too high, and the average tensile strength, when air dried, of 600 pounds per square inch, is one of the highest that has ever been recorded

The clay burns to a red colour At cone 010 the fire shrinkage was 2 4 per cent and absorption 7 8 per cent, at cone 05, fire shrinkage 4 3 per cent and absorption 3 5 per cent; at cone 03, fire shrinkage 7 0 per cent and absorption 0 per cent; the clay softens at cone 5.

It shows a tendency to black core and bloat, and is not a very desirable material to use alone.

A dry-press bricklet was also tried, and burned to a good red brick at cone 03, except for the fire cracks. The clay although occurring in the same formation as that at Leary, does not work up as well The gypsum scales also form white specks in the burning.

Owing to the sticky plastic character of the clay, it would be difficult to uniformly incorporate any sand with it, unless it were dried and ground before doing this However, the experiment was made of mixing in 33 per cent of sand, but even then the body was still very stiff and would not stand fast drying. The addition of sand reduced the air shrinkage to 7 per cent.

At cone 010 the fire shrinkage of this mixture was 0 per cent and the absorption 14 1 per cent. At cone 05 the fire shrinkage was 3 per cent and absorption 8 per cent.

The addition of the sand, therefore, reduces the fire shrinkage and opens up the body, but even so the mixture would probably cause trouble in working.

Preheating and weathering might possibly improve the clay, but no money should be expended for the installation of a plant, until the material is thoroughly tried out.

There are a number of cuttings extending for several miles north of this point, and all showing similar material The shale occurs mostly as cores in boulder clay spurs which lead from the level uplands to the lake shore There are no natural outcrops and the presence of the shale would be quite unsuspected if it were not for the excavations made for the railway The shale exposed at Regina Beach station, and for a mile or

more north of this point, contains a large quantity of plates and crystals of gypsum, as well as ironstone nodules.

A sample of the gypsiferous shale from Regina Beach (1804) was tested in the laboratory

This is a stiff sticky, shale, which cracks in air drying. It could not be wet-moulded, and some dry-press bricklets were tried, but while these could be moulded, they cracked badly in a 12 hour burn to cone 010.

The material is not recommended for bricks, but it could probably be used for making burned-clay railway ballast.

No shales were observed in the heavy cuttings of the Craven-Colonsay branch, along the east shore of Lost Mountain lake. These excavations are all in an exceedingly compact, dark-grey, gritty boulder clay, which contains numerous small rounded pebbles.

BELLY RIVER FORMATION.

The wide distribution of this formation can be seen by reference to the geological map, but it is well to repeat here what has been said before, viz., that while it underlies a very large area there is usually such a heavy mantle of Pleistocene material that outcrops are scarce. The Belly River shales are consequently to be sought for only in the deeper valleys, although even there the shale beds may not be continuous, partly because the surface of the bed rock is uneven, and the covering of later clays and silts may extend below the river level in places.

Attention has been called to the fact that the Belly River shale deposits are of lenticular character, and that neighbouring lenses are not necessarily alike, a fact that points to the need of careful prospecting in the search for suitable materials.

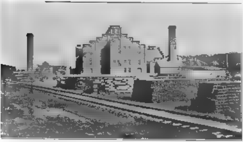
Taking the case of two beds, lying one above the other, we find that one may fuse at cone 1, while the upper may stand cone 18, or one may dry without cracking while the other gives much trouble from this cause, or again one may burn buff, while the other burns red.

These statements should not be interpreted to mean that the lenses are small, for many of them are of considerable size.

PLATE IX

Railway cuttings in Niobrara shale and boulder clay
West shore of Lost Mountain lake, Sask.

PLATE X



Works of the Alberta Clay Product Company,
Medicine Hat, Alta.

We feel it necessary, however, to caution investors to test the clay properly before constructing a clay plant, for we know of instances where much money has been expended in setting up machinery to work some of these clays into products for which the raw material was unsuited. It seems to us possible to determine this beforehand, and indeed we have been able to do so in our laboratory tests.

Lying as the Belly River formation does, in central and southern Alberta, it should be seriously considered by the manufacturers of clay products, and yet up to the present time it has been utilized only in the vicinity of Medicine Hat.

Medicine Hat, Alberta. In our report of last year a description was given of the plant of the Alberta Clay Products Company, located at Medicine Hat, and also of the clay bank which was being opened up near Coleridge.

Since then the plant has been completed and put in operation, the products consisting chiefly of dry-pressed brick and fireproofing.

The plant is equipped with drypans, inclined screens, wetpans, pipe press, and dry-press machines.

There is a large five story drying building with slatted drying floors, and pipe coils underneath them. The temperature in this house is kept at about 80° F.

It was originally planned to utilize these floors for drying sewer-pipe, but since the clays at Coleridge are not found suited to this, the building has been used for drying fireproofing.

The clay for the dry-press brick is ground in dry pans, screened and sent to the dry-press machines. From these it is wheeled to the kilns. The Company had several scove kilns in operation and also several circular down-draught kilns. All the burning is done with natural gas obtained from wells near the factory. A view of the latter is shown in Plate X.

Coleridge, Alta.—The clay deposit of the Alberta Clay Products Company is in the ridge overlooking Bull's Head creek and was described in our report of last year. There it was pointed out that the deposit consisted of a number of lens-

shaped masses of clay shales, and some sandstones, the whole forming a series of considerable thickness.

In the 12 months interval between our first and second visits, considerable work has been done at the first opening (Plate XI), and a new opening has been made to the southwestward along the ridge.

The greater extent of section shown by these openings, confirms what we said in last year's report regarding the lenticular character of the deposits.

Thus for example, the black clay (1692) noted in last year's report, has thinned out to a few inches. The lens of so-called sewer-pipe clay referred to in the same report has also thinned out, but in 1911 the Company was working a bed of brownish clay (1754), which occurs at about the same level as the sewer-pipe clay referred to above, but is farther in the bank and is used for making fireproofing. This is capped by a sandstone layer.

Somewhat higher in the hill than the fireclay referred to last year, and lying also farther to the northeast is a lens of black clay, which is claimed to stand a temperature of 2,800° F

It is a smooth plastic clay (1753) and contains small scattered gypsum crystals, but cracks in air drying No test was made of it.

The dry-press clay in 1911 was being taken chiefly from the new opening, but not enough excavating had been done to give us a correct impression of its size.

The following laboratory tests were made on samples collected in the summer of 1911

Fireproofing Clay, Coleridge, Alberta —This material (1754) is a soft-yellowish sandy shale, with limonite nodules and much grit. It worked up with 20 per cent of water to a mass of fair plasticity, and sufficient smoothness to flow through a die. The grittiness is brought out by the fact that it contains 27 per cent of sand which is retained in a 200 mesh sieve. The average air shrinkage, viz., 5 per cent, is not high, but the clay will not stand rapid drying.

The average tensile strength when air dried is 294 pounds per square inch.

PLATE XI

3553—p. 30 View of main excavation of Alberta Clay Products Company, at Coleridge as it appeared in July, [illegible]

In burning the wet-moulded bricklets behaved as follows -

Cone.	Fire shrinkage.	Absorption.	Colour
	%	%	
010	0	16·5	Salmon.
06	0	15·2	"
03	0	13·2	Light red.
1	2·6	6·5	Red.
3	4·0	1·5	Brown.
5	Fused.		

These tests indicate that the clay burns to a good hard body at cone 010, even though it is not steel hard. The colour is not bright, but for fireproofing this makes little difference. The absorption is not high, and at cone 1 is even rather low for this class of clay product.

It is probable that the clay could be mixed with sawdust to make terra-cotta lumber, but this is impracticable at Medicine Hat because of the difficulty of getting sawdust.

Dry-press Brick Clay, Coleridge, Alta. (1755).—The material used for dry-press brick is a light yellowish-grey, massive clay, which worked up with 22 per cent of water to a very plastic, sticky mass, that was difficult to work. Small bricklets did not crack in slow drying, but full sized ones did. This then rather precludes the forming of bricks from this clay by a plastic process, unless it is preheated.[1] The average air shrinkage of wet-moulded bricklets was 7 per cent, and the tensile strength when air-dried is high, but could not be accurately measured as it was difficult to get briquettes free from flaws.

Wet-moulded bricklets behaved as follows in burning —

Cone.	Fire shrinkage.	Absorption.	Colour
	%	%	
010	0	10·1	Light red
06	1·6	6·5	"
03	1·7	5·5	Red
1	3·3	2·1	"
3	Passed vitrification.		
5	Fused.		

[1] See Chapter on pre-heating experiments.

It is unfortunate that this clay will not work by a plastic method without preheating, since it has a low fire shrinkage and burns to a good dense body at a low cone. It is not refractory, as it fuses at cone 4.

The wet-moulded bricklets were steel hard at cone 05, and also showed scumming.

A dry-press bricklet burned at cone 03, had a fire shrinkage of only 2 per cent, and an absorption of 7.9. It also burned to a good red colour.

Bull's Head Creek Valley, Alta.—The valley of Bull's Head creek (Plates XII and XIII) extends southwestward from Coleridge for some miles, its broad flat bottom being bordered on either side by somewhat steep slopes, which as a rule show few outcrops, for the reason that the shaly beds usually mellow down and become covered by a mat of grass. The sandstone beds which are more resistant usually stand out as narrow ledges on the valley sides.

For about 3 or 4 miles (estimated) up the valley from the clay pits near Coleridge the valley is very broad and there are no outcrops, but at this point it contracts somewhat, and some clay exposures appear.

Here on the northwest side of the valley there are exposures of clay lenses, some of them very sandy and interrupted by beds of sandstone. There is also a black clay closely resembling the one (1691) found in the bank at Coleridge.

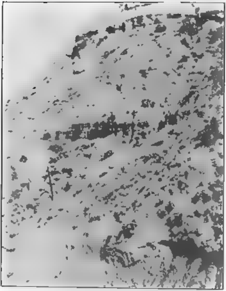
About one-fourth mile north of here, we took a sample of a 7 foot bed of clay (1756) which outcrops near the base of the slope on the northwest side of the valley.

Another sample (1757) is a dark brownish-grey shale which outcrops on the northwest side of the valley, at a point lying S. 30° W. from the Coleridge clay pit. The lens is not less than 12 feet thick, and outcrops at two places about 300 feet apart.

About 1 mile farther (Plate XV) there is a small butte rising up from the lower slope on the southwest side of the valley.

General view of valley of [illegible] creek [illegible] looking northeast

View looking up valley of Bull's Head creek from a point about 4 miles southwest of Coleridge



Beds of shale in valley of Bull's Head creek Alta

The section of this is as follows.—

Sandstone	4 ft.
Shale (1758)	30 "
Sandstone	1 "
Shale	15 "
Concealed lower slope perhaps underlain by shale	

These shales appear to continue as far as a horse ranch, where the wagon road leads out of the valley to the north.

Beyond this, that is farther up the valley, the shales seem to be replaced by beds of coarse, greyish and yellow sand, with occasional sandstone beds. These hard beds are due no doubt, in many cases, to the induration of the sands.

At only one point was any good clay found, and this resembled that outcropping in the butte farther down the valley and referred to above.

It is possible that further prospecting might develop good beds of clay in this valley, although it is doubtful if it would pay to develop any beds farther up the valley than we went, as the stream turns to the southward and the distance from the railway is too great.

Up to the point reached by us, the valley is not far from the line of the Canadian Pacific railway running from Medicine Hat to Lethbridge, and Bull's Head station on this line is at no great distance.

The following laboratory tests were made on samples collected from the valley of Bull's Head creek.

Light-grey Shale, Bull's Head Creek, Alta. (1756.)—This is a somewhat hard and very gritty clay shale, which shows a tendency to crack in air drying, even when moulded in small test bricklets. Its plasticity is high.

The average air shrinkage was 6·8 per cent. and wet-moulded bricklets behaved as follows in burning:

Cone	Fire shrinkage.	Absorption.	Colour
	%	%	
010	0	11·1	Light red
05	0·3	9·1	Red.
03	2·7	3·3	"
5	Vitrified.		

The clay burns to a brick with good ring, low fire shrinkage, and moderate absorption even at cone 010, but it could not be used without preheating. Otherwise it is to be classed as a brick or fireproofing clay.

Dark Yellow to Grey Shale, Valley of Bull's Head Creek, Alberta (1757).—This is a highly plastic clay, which works up with 21 per cent of water. It has to be dried slowly as large bricks show a tendency to crack in fast drying. It is, however, somewhat safer to dry than No. 1756.

The average air shrinkage is somewhat high, being 8 per cent in the hand-moulded bricklets.

The burning tests of the wet-moulded bricklets were as follows:—

Cone.	Fire shrinkage.	Absorption.	Colour
	%	%	
010	0·7	10·8	Salmon.
05	2·0	4·8	Light red
03	3·6	2·4	Red.
1	Vitrified.		
3	Fused.		

This clay burns to good hard body and would make a good brick and fireproofing clay, but an objection to its use is the tendency to crack. When moulded dry-press, however, it gave excellent results, and a good hard red body. At cone 05 the dry pressed bricklet was steel hard, fire shrinkage, 1·5 per cent, and absorption 9·5 per cent. At cone 03, the colour was deep red, fire shrinkage 4 per cent, and absorption 5·2 per cent.

This seems to give a better dry-press at 03 than the clay mined for that purpose at Coleridge.

Yellowish Shale from Upper Part of Butte in Valley of Bull's Head Creek, Alberta (1758).—This clay is somewhat soft and worked up with 20 per cent of water to a mass of good plasticity, and smooth texture. A small test-brick dried

rapidly without cracking, but a full sized one would not stand fast drying, in fact it had to be dried very slowly.

The average air shrinkage was 7 per cent, and the average tensile strength when air dried was 234 pounds per square inch

The wet-moulded bricklets gave the following results in burning.

Cone.	Fire shrinkage.	Absorption	Colour
	%	%	
010	0	9·6	Light red.
05	0·7	9·6	"
03	1·7	6·3	"
1	3·0	4·2	"
3	Fused.		

This clay is similar to the preceding, but does not darken quite as much in the burning. It is nearly steel hard at cone 010

At cone 05 it made a fine-grained dry-press brick of good red colour, with 1 per cent of fire shrinkage, and 13 per cent absorption

This clay is worth looking into for dry-press brick manufacture. It is also sufficiently smooth and plastic to flow through an annular die. Experiments made in this way gave a good drain tile, with 9 6 per cent air shrinkage. At cone 010 the tile burned to a good red colour, 1 per cent fire shrinkage. At cone 08 the tile was slightly deeper in colour and gave 2 per cent fire shrinkage.

This locality is about 3 miles from Bull's Head station.

Inspection of the map of southern Alberta also indicates the possibility of finding the shales along the valley of Seven Persons creek, but an examination of this section as far as Seven Persons station on the Canadian Pacific railway showed that the river valleys seem to be cut entirely in glacial drift.

This emphasizes the point that we made in our report of last year, viz, that the surface of the Belly River shale forma-

tions is exceedingly irregular, and at places buried under a heavy overburden of glacial drift.

Taber, Alberta.—There are several coal mines in the immediate vicinity of Taber, but as the shale measures lie practically flat, and the coal is some distance below the surface, most of these mines are operated by means of vertical shafts.

Along the Belly river however, 2 miles north of Taber, there are a number of small mines, all of which appear to be working the same coal seam.

On the south side of the river the Canadian Pacific railway has a small mine in operation about 30 feet above the river level. The seam here is a lignite 4 feet thick, and is overlaid by sandy clay. The section below the coal shows in the face of the bank above the river, and consists mostly of brownish sandy clay with limonitic sandstone layers, which passes upward into shale about 6 feet below the coal.

This point is perhaps 1,000 feet from the bridge over the river. As the section is traced towards the bridge, this clay shale increases in thickness, and at about 200 feet east of the bridge an attempt has been made to utilise it in the manufacture of common brick.

This (1791) is a soft dark-grey shale which worked up with 26 per cent of water to a very plastic, smooth, but rather sticky body. However, in spite of its stickiness it worked up fairly well, and is sufficiently plastic to flow through an annular die. The average air shrinkage is 8 per cent and the clay will not stand rapid drying, it also scums badly.

The burning tests were as follows:—

Cone.	Fire shrinkage	Absorption.	Colour
	%	%	
010	1·0	12·5	Light red.
05	5·3	8·1	"
03	5·8	5·2	"
1	Past vitrification		"
2	Fused		

Plate XV

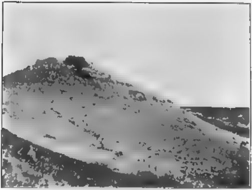


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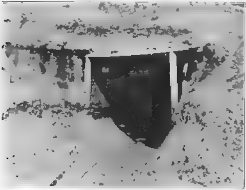
Plate XVI



[illegible]

This clay could be used for common brick, if properly burned. It is also referred to in the chapter on roofing-tile tests.

On the north side of the river, at the mine of the Superior Coal Co. (Plate XVI) the lignite seam is about 4 feet thick. It is underlain by about 3 feet of dark and somewhat gypsiferous shale, which extends to the floor of the mine.

Overlying the coal there is a 6 to 8 inch layer of rusty sandstone, which in turn is overlain by yellowish-brown iron stained shale

A sample of the under clay (1792) was tested with the following results.

This is a very plastic, smooth, black shale, which worked up with 27 per cent of water to a stiff mass, whose average air shrinkage was 8 per cent.

It burned to a red colour, and its fire shrinkage at cones 010 and 05 was 1·7 and 3·4 per cent respectively. The absorption at these cones was 10·9 and 5·0 per cent.

The clay burns to a good brick but has to be fired very slowly in order to burn off the carbon. If this is not done, black coring and swelling results.

It could be worked in connexion with the lignite bed

Rock Springs, Alberta.—The Rock Springs mine of the Superior Coal Co. is located about 2 miles west of Taber. The coal seam, which is reached by means of a shaft, has clay both above and beneath it. The following two analyses made by Herbert Carmichael, show the composition of No. 1, the top clay, and No. 2, the bottom clay

	1	2
Silica	63·3	68·4
Alumina	19·2	18
Iron oxide.	5·4	4
Lime	0·6	0·4
Magnesia.	1·2	1
Loss on ignition	9	7·7

Samples for laboratory tests were taken of both the top and bottom clay, and the results of these are given below

Bottom Clay, Rock Springs Mine, Superior Coal Co.—This (1793) is a dark-grey soft shale, which worked up to a very smooth plastic mass that cracks in drying.

When 1 per cent of salt was added to it, it worked up with 22 per cent of water to a rather sticky, tough mass, that was hard to work wet-moulded.

The salted clay has 8 per cent air shrinkage, and an average tensile strength of 154 pounds per square inch.

The wet-moulded bricklets of the salted clay burned to a red colour. These at cone 010 had a fire shrinkage of 1 per cent, and an absorption of 6·7 per cent. At cone 05 the fire shrinkage was 3·3 per cent and absorption 6·3 per cent. The clay fused at cone 3, and had to be burned very slowly to prevent black coring and consequent swelling.

Top Clay, Rock Springs Mine, Superior Coal Co. This (1794) was a soft brownish shale, containing much gypsum. It worked up with 22 per cent of water to a mass of good plasticity, but which was rather stiff and sticky. The average air shrinkage was 8 per cent, and the average tensile strength 324 pounds per square inch.

Wet-moulded bricklets behaved as follows.

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	0	16·1	
05	3	9·6	
03	6	3·7	
1	Past vitrification		
2	Fused.		

The clay burns to a good red body, and could be used for brick.

Since it will also flow through an annular die it might be used for fireproofing, but there is a question as to whether it might not have to be dried on floors instead of in tunnels.

A dry-press mixture of 1793 and 1794 was tried, and this gave a good hard dry-press brick, of red colour, but which was speckled with small white grains of the calcined gypsum. At cone 05 the fire shrinkage was 5 per cent and the absorption 9 per cent, while at cone 03 the fire shrinkage and absorption were both 7 per cent.

CHAPTER III.

Laramie Formation.

In referring to the distribution of the Laramie formation in last year's report attention was called to a large triangular area in southern Saskatchewan, which includes the Souris coal field and the Dirt hills. Special attention was given to the latter because they contain large quantities of refractory clay, which are to be regarded as an important mineral asset of the Province.

Dirt Hills, Sask.—The clays specially described occur in section 28, township 12, range 24, west of the 2nd Meridian. Preparations are now being made to utilize these for the manufacture of pressed and firebrick.

The southern extension of these beds was examined during the field season of 1911, particularly on section 24, township 12, range 24, west of the 2nd Mer where operations have begun for mining lignite, and for the development of the clays associated with it (Plate XVII).

The lignite seam outcrops in a coulee, running in an east-west direction, at the base of the hills, on the northwest of section 24 It is overlain by impure grey shales, and underlain by white or light grey fireclays, the latter being exposed on both sides of the coulee for several hundred feet.

The lignite appears to occur in a small basin of limited extent and no great thickness. It is replaced by white clay towards the east, and a shaft sunk to a depth of 105 feet on the ridge to the south failed to find it at the expected level.

The arrangement of the deposits as seen on the south side of the coulee appears as in Plate XVIII.

The grey shale above the lignite has an exposed face of about 7 feet in height. It contains some layers of small ironstone concretions, and vertical rusty streaks. The overburden of drift is light, but this may become heavier as the shale is worked backward into the ridge

A sample of this clay (1805) was taken for examination. When ground and mixed with 32 per cent of water, it formed a very smooth plastic mass, but one which was rather stiff and hard to work. The air shrinkage was 9 per cent, and the average tensile strength when air dried 383 pounds per square inch.

Wet moulded bricklets gave the following result on burning.

Cone	Fire shrinkage	Absorption.	Colour
	%	%	
010	1·8	19·2	Light red
05	5·6	1·4	Red.
1	Fused		

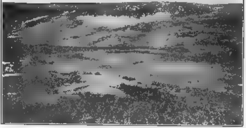
The air shrinkage of this clay is too high, the working qualities are bad, and the fusing point low. It makes a steel hard brick at cone 05, but at this temperature the fire shrinkage is excessive, and accompanied by warping.

If dry-pressed, and burned to cone 05, this clay makes a steel-hard brick, with absorption of 7·3 per cent, but the shrinkage is high and the colour poor.

With the addition of 25 per cent of sand, the working and drying qualities of the material are much improved, the air shrinkage is reduced to 7 per cent, while the fire shrinkage at cone 010 is zero, and the absorption 16 per cent.

With the addition of sufficient sand this shale will make common red brick of fairly good quality by the soft-mud process. It might also be used in a stiff-mud machine for wire-cut brick or drain tile, but the wares thus made will not stand fast drying. A 3 inch tile of the clay was run through an annular die, and gave a good pipe at cone 08.

The white clay which forms the basin for the lignite was found to be sandy in character, but the deposit varies in this respect. A boring made below the lignite seam for a depth of



White sandy fireclay exposed in a coulee, Dirt hills, Sask.

Openings made for mining lignite on Sec. 24, Tp. 12, R. 24, W. of 2nd Mer.

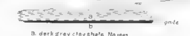


Fig. 2. Diagram showing arrangement of clays and lignite in the above photograph.

7 feet did not reach the bottom of it, and its thickness to the eastward where it is found replacing the grey shale and lignite must be considerable.

Notwithstanding its sandy character this clay (1808) when tempered with 27 per cent of water forms a very plastic and fairly smooth mass. Its air shrinkage is 5 per cent, and tensile strength about 120 pounds per square inch. The burning tests resulted as follows:—

Cone	Fire shrinkage.	Absorption.
	%	%
1	8·0	9·3
5	2·0	9·1
9	8·5	6·4
31	Fused.	

As can be seen from the fusion point given above, this clay is undoubtedly refractory, and should be of use in the manufacture of the different kinds of wares in which such material is employed.

A portion of the sample No. 1808 was submitted to a washing test, and gave 50 per cent of a fine washed product, free from grit. The washed clay is exceedingly smooth and plastic, somewhat resembling ball clay used as the plastic ingredient in pottery mixtures for whiteware bodies.

In the table following (A) there is given the chemical analysis of a washed sample of No. 1808.

For purpose of comparison there are also given herewith the analyses of several other clays as follows B, from Salina, Pa., C, from Woodbridge, N.J., and D, from Dickinson, N. Dak.,[1] but while this is from the same formation as the Dirt Hills clay, it represents the unwashed clay.

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[1]Clapp. N. Dak. Geol. Surv., 4th Bien. Rep't 1906.

—	A	B	C	D.
Silica	51·94	51·92	51·56	66·55
Alumina	33·62	32·80	35·04	23·22
Iron oxide	1·5	1·13	0·78	1·16
Lime.	0·23	0·03	tr	0·29
Magnesia	trace	0·44	tr	0·61
Potash	0·82	0·40	tr	undet
Soda	0·22			undet
Sulphur trioxide	none			
Loss on ignition.	11·44	13·49	12·50	7·08

The air shrinkage of wet-moulded bricklets made from the washed clay was 7 per cent.

The clay exposed on the north side of the coulee (Plate XVII) is of bluish-grey colour, and very plastic in the upper part of the bed, but becomes more gritty and is yellow, probably from iron staining, towards the lower portion. The thickness of this deposit is unknown, and the sample which was taken was the average of a face about 6 feet.

This clay (1807) when mixed with 27 per cent of water forms a highly plastic, and rather sticky mass. The air shrinkage was 9 per cent. The tensile strength is very high, being 455 pounds per square inch for the air-dried clay.

Burning tests of wet moulded bricklets are as follows:—

Cone.	Fire shrinkage.	Absorption.	Colour
	%	%	
010	1·7	11·6	Buff.
05	4·0	7·0	"
03	4·3	7·5	"
1	4·3	6·8	"
3	5·7	4·9	"
5	6·3	2·3	"
9	6·7	0	Grey
23	Fused.		

This material may be classed as a stoneware clay, and in addition to making common stoneware articles, the clay could be used for ornamental pottery with a coloured glaze. It burns to

PLATE XIX

Erratic blocks of limestone. Dirt Hills, Sask

dense light-buff body at cone 5, while at cone 9 it forms an impermeable body of light-grey colour The bricklets were steel hard even at cone 010.

This clay might be used in the manufacture of glazed architectural terra-cotta, if sufficient grog was added in order to lessen the shrinkage, which is rather high.

Dry-pressed and burned to cone 03 the clay makes a fine buff facing brick of pleasing colour and steel hard body, with a fire shrinkage of 4 per cent and 10 per cent absorption.

Clays number 1805, 1807, and 1808 were mixed in equal

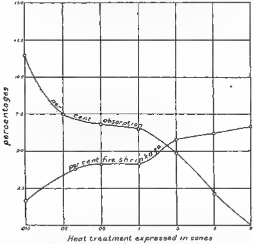


FIG. 3.—Absorption and fire shrinkage curves of clay 1807 from Dirt hills, Sask

proportions, and short lengths of 3 inch pipe made from this mixture in a hand press.

These were burned in a commercial sewer-pipe kiln at 2200°F. and resulted in a smooth salt-glazed pipe.

Bricklets made from this mixture showed a total shrinkage of 14 per cent, and an impermeable body when burned to cone 3.

This mixture is well worth trying for the manufacture of sewer-pipe. The ware might be improved by using a mixture containing a larger proportion of the sandy fireclay.

Dry-pressed bricks made from the above mixture have a pink tone, steel-hard surface, and about 8 per cent absorption at cone 03. These bricks should prove a desirable material for facing city buildings.

This clay becomes whiter and more sandy, like No. 1808, as the outcrops are followed eastward along the ridge on the north side of the coulee towards the Plains. Where the ridges merge into the plain the white clays disappear, and are followed by soft brown sandstones, which appear to underlie them.

Going towards the hills from the white-clay beds only an occasional hard band of sandstone is seen outcropping on the open grassy slopes, until about half a mile distant, where the ridges become more broken, some knolls denuded of covering show the bedded deposits again. These knolls are composed of dark coloured clays, brown sandy shales and sands, and capped by a thick and partly indurated sand bed, which has evidently protected them temporarily from erosion (Plate XX).

An average sample for testing purposes was taken from the face of one of these knolls, and when tempered with water worked up to a sticky mass, which when moulded and set to dry showed abnormal cracking. Dry-pressed bricklets made from it cracked badly in the firing.

The clay fuses at cone 1.

It is useless for the manufacture of clay products.

Some small samples of light-grey clay from section 11, in the same township and range as the above, were submitted for examination by E. J. Wenger of Regina. These clays occur higher up in elevation than the beds from which samples 1807 and 1808 were taken, but they are of similar quality. They are also said to be of sufficient thickness for working, but it is not known whether they would have to be worked by underground methods, or if they were situated in such a manner that the open-cut method of mining could be used.

PLATE XX

Knoll of brown sandy shale and soft sandstone
Dirt h[illegible]s Sask

[illegible] XXI

View of plains near S[illegible] 9 miles south of [illegible] Sask
The v[illegible] s[illegible] by shales

A large portion of the body of white-sandy fireclay on both sides of the coulee in section 12 could probably be worked by the open-cut method, when the light overburden of sand and gravel was removed with scrapers. A supply of clay could then be easily obtained to keep a plant going for some time, before having to resort to underground mining.

Owing to the irregular arrangement of the beds in this formation, no definite statement of their extent should be accepted in advance of systematic prospecting by borings, especially when the outcrops are few in number.

A small sample of white sandy clay said to have been obtained on township 7, range 27, west of the 2nd Meridian, was submitted to the writers by Mr. McNair of Moosejaw. This material was a fireclay, and identical in character with sample 1808, although situated in a locality about 35 miles distant in a southwesterly direction from the deposit in which the latter was obtained.

Wood Mountain, Sask.—White clays of similar character are reported by D. B. Dowling of the Geological Survey, to exist in Wood mountain, and white clays described by R. G. McConnell, occurring in quantity on the Frenchman river in southwestern Saskatchewan, are probably of the same nature.

Cypress Hills, Sask.—Some very white sandy clay was obtained during the course of the present investigation on the summit of the Cypress hills, a few miles south of Belanger. A shaft sunk at this point passed through a thin sheet of drift into the white clay for a distance of 6 or 7 feet.

A small sample of this clay (1773) taken from the dump at the shaft gave the following results:—

It is an exceedingly sandy clay which with 20 per cent of water worked up to a mass sufficiently plastic for moulding, and whose average air shrinkage was 4 per cent.

Only a few burning tests were made of the wet-moulded bricklets. These burned to a moderately hard light-buff body with 11 per cent absorption at cone 1.

At cone 9 the colour was grey, fire shrinkage 4 per cent, and absorption 4 per cent.

It is unaffected at cone 20, but fused at cone 27, and might, therefore, be regarded as a low-grade fireclay, suitable probably for boiler brick or pressed brick.

Forward, Sask. The Canadian Pacific railway has recently constructed a new branch from Weyburn on the Moosejaw Portal branch, westward to Forward and Ogema, the latter being the last town on the line in the summer of 1911. Although this line does not strike the Dirt hills, still it passes a short distance to the south of them, and it was thought that possibly the cuts along it might have exposed some of the Laramie clays. With this idea in view an examination of all cuttings was made along the track between the two villages mentioned, but nothing was found except drift material.

Stowe, Sask.—As no Laramie clays were found around Forward or Ogema, an examination was made to the southward, towards Stowe (Plate XXI).

This town is located on a new branch of the Canadian Northern railway, about 11 miles south of Forward. The Souris river flows past the town, and on the south side of the river at the base of the slope, and near the wagon bridge, there is an outcropping of greyish-white plastic clay, whose occurrence is interesting, because of its similarity to the white clays found in the Dirt hills farther to the north. Not more than 2 feet are exposed, and it was difficult to determine whether this represented material in place, or simply an inclusion in the glacial drift. If the clay is in place, it underlies a considerable thickness of overburden.

As bearing on the possibility of its being in place, it may be mentioned that lignite is found in the gully below the road level, and consequently underlying the white clay.

We were also informed that white clay had been struck in boring higher up on the slope, and at a point about half a mile southwest of the wagon bridge.

The exact location of the first white clay mentioned seems to be in the northeast quarter section 30, township 6, range 18.

In the railway cut at Stowe there is a long low outcrop of soft yellowish sandstone, having apparently a rather steep dip and underlying brown and soft bluish-grey smooth shale, the whole series dipping eastward

The soft sandstone also outcrops just west of Stowe along the road near the creek.

The entire series dips east about 20°, and if the strikes around here are persistent and uniform, these clays and shales must overlie the greyish-white clay found across the creek.

Some samples were taken of the shale in the railway cut at Stowe, but unfortunately they never reached us.

Following up the Canadian Northern track west of Stowe, there are several deep cuts, but none of these show anything but drift clay. The whole contains not a few fragments of Cretaceous shales.

CHAPTER IV.

Edmonton Formation.

The general area underlain by this formation is shown on the geological map, and in last year's report we gave the tests of several samples of Edmonton shale, taken from somewhat widely separated localities, such as Cowley, Lundbreck, Edmonton, and Entwistle, all in Alberta.

Some of these were revisited in 1911 to ascertain what further developments had taken place, and in addition a number of new localities were looked into.

The general conclusions to be drawn from this summer's work are that in some parts of the Edmonton formation there are some excellent shales.

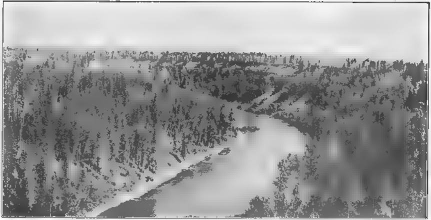
Edmonton, Alta.—The several brick yards around Edmonton were mentioned in last year's report, and it was stated at that time that there was under consideration the development of clays on the Strathcona side of the river, the company organized to develop these being known as the Western Clays, Ltd. Since our first visit there the shale deposit has been opened up more exposing a bluish shale with some scattered concretions in the upper part of the section, and this material was being utilized in the summer of 1911 for the manufacture of dry-press brick.

It lies deeper than any of the beds from which last summer's samples were taken.

A sample of this was tested, and the results are given below.

It is a very plastic, stiff, and sticky clay (1772) which worked up with 25 per cent of water, and whose air shrinkage was 10 per cent. The average tensile strength was 316 pounds per square inch. The clay flows smoothly through an annular die, but has to be dried slowly to prevent cracking.

PLATE XXII



3553—p 48

Gorge of Pembina river west of Entwistle, Alta

The wet-moulded bricklets behaved as follows in burning —

Cone	Fire shrinkage	Absorption.	Colour
	%	%	
010	0·6	12·80	Light red
05	1·6	11·0	Red.
03	2·3	10·6	"
1	6·6	0·0	Brown.
3	Fused		

The shale shows a low fire shrinkage, not too high absorption, and gives a good body Some circular tiles were pressed through a die Their air shrinkage was high, viz , 11 6 per cent, but they burned to a good body with 1 per cent fire shrinkage at 08, and the body nearly steel hard.

The shale can be moulded dry-press, and this process was being used at the time of our visit.

Entwistle, Alta.—This town is situated on the Grand Trunk Pacific railway about 60 miles west of Edmonton. The Pembina river is crossed by the railway about one mile west of Entwistle, and the Lobstick river flows into it from the west about three-fourths mile north of the railway.

The region is underlain by Tertiary shales and sandstones, the sandstones being above the shales in the section exposed. Consequently since the strata are practically horizontal, there will be on the lower ground less thickness of sandstone overburden.

The gorge of the Pembina river where the railway crosses it (Plate XXII) is 190 feet deep, and on the east side, as the illustration shows, the sandstone capping is about 50 feet thick, but on the west side it is small There is hardly a possibility of working the shale under the sandstone.

Along the Lobstick, however, there is little or no sandstone overburden close to the river

In our last year's report we gave a section along the Lobstick river, which had been supplied us by Mr C. C Richards,

and the bank on which this section was measured is shown in Plate XXIII

This locality was visited by us this summer and an additional sample was taken from a 6 foot bed beginning 2½ feet below Mr Richards' section. The lower 18 inches of this was sandy.

Across the river from this section, and just northeast of the office, the steep bank shows another section of shales and sandstones, not less than 35 feet in thickness.

The upper 7 feet (1762) consists of blue shales, including a sandy layer at the bottom. Below this are 11 feet of blue shales which extend down to the sandstone bed which is about 15 inches thick. The bottom of this sandstone layer is about 20 feet above the river.

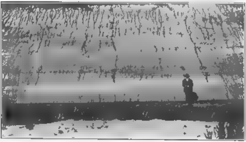
All of these shales weather down to a very plastic mass.

The shale deposit which is near the office is not in as high a bank as the one on the other side of the Lobstick river, and forms a more workable mass.

It is possible that this shale may extend back from the river bank to the southward for a considerable distance, but there is no knowing whether the surface of the rock is level or not, and how much glacial drift overburden there is. Thus on the opposite or north side of the river from the office, a coal shaft which was put down struck the coal at about 140 feet, but overlying this found a considerable thickness of drift. There are also good cut banks of shale at the junction of the Lobstick and Pembina rivers, as well as along the Pembina near this point. The following tests were made of these shales.

Shale From 6 Foot Bed, Along Lobstick River, Near Entwistle (1761) —This is about 2½ feet below the base of Richard's section, given in last year's report. The material is a calcareous grey shale containing much fine grit, which worked up with 24 per cent of water to a mass of medium plasticity, whose air shrinkage was 5·4 per cent. It stands rapid drying without cracking.

Section of Edmonton series on Lobstick river northwest of Entwistle Alta



Shales and sands of Edmonton series, near Gwynne Alta showing irregular character of the bedding

Wet-moulded bricklets behaved as follows in burning —

Cone	Fire shrinkage	Absorption.	Colour.
	%	%	
010	0	18·0	Light red.
05	1·0	1·2	" "
03	2·5	10·3	" "
1	5·4	3·5	Dark red
3	Vitrified		
5	Fused		

This is a good brick shale, and could, no doubt, be used also for dry-press brick and fireproofing.

Upper 7 Feet of Shale, Bank of Pembina Coal Company, Behind Office, Entwistle (1762) —A soft yellowish shale which contains much fine grit, but worked up with 24 per cent of water to a mass of good plasticity, whose average air shrinkage was 6 per cent, and average tensile strength when air dried 225 pounds per square inch.

The material is sufficiently plastic to flow through a 3 inch annular die, and stood moderately fast drying.

Wet-moulded bricklets yielded the following results —

Cone	Fire shrinkage	Absorption.	Colour
	%	%	
010	0	14·5	Light red
05	1·7	9·9	" "
03	4·0	6·7	Red
1	4·3	5·0	"
3	7·3	0·0	Brown.
5	Past vitrification.		
7	Fused.		

The fire shrinkage is not excessive, and the absorption is not high. The colour is excellent, and the body has a good ring

at cone 010. At the other cones the colour is deeper, but not very dark until cone 1.

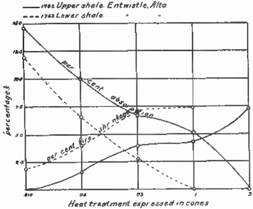


Fig. 4.—Absorption and fire shrinkage curves of shales from Entwistle, Alta.

It is a good red-brick clay and commends itself also for fire-proofing. There is also a strong probability that the clay could be used for sewer-pipe

We had no difficulty in making 3 inch cylindrical tile from the clay These burned to a good red body, of smooth surface, at cone 010.

Lower 11 Feet of Shale, Pembina Coal Company, Entwistle, Alta. (1763.)—This is a grey shale which is partly mellowed by weathering. It worked up with 22 per cent of water to a rather smooth mass of good plasticity and worked somewhat better than 1762.

The average air shrinkage was 5 7 per cent, and the average tensile strength when air dried was 114 pounds per square inch.

The wet-moulded bricklets behaved as follows in burning

Cone	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	2	12	Light red.
05	4	6·4	Red.
03	7	2 7	"
1	7·3	0·0	Dark red
3	Fused		

The clay will not stand rapid drying, but it burns to a good red body, having a good ring at cone 010, and a low absorption even at cone 05 It is not refractory enough for sewer-pipe, but should work well for fireproofing and drain tile.

It would probably work alone for dry-press, and a mixture of equal parts of 1762 and 1763 was tried This gave a splendid dry-press brick at cone 03, whose fire shrinkage was 7 per cent and absorption 9 2 per cent. It would probably yield a good dry press brick even at cone 05.

Camrose, Alta —There are numerous outcrops of the clays and shales of the Edmonton series along the valleys of the Battle river, and its small tributaries in the vicinity of Camrose, Alta., but the cuttings on the branch lines of the three principal railways which intersect at this town, afford the best sections

Wetaskiwin, Alta About 5 miles east of Wetaskiwin, flat lying sandstones, interbedded with shales, are first seen on the Winnipeg and Edmonton branch of the Canadian Pacific railway From this point eastward, these rocks recur at intervals in the cuttings for several miles.

Most of the sections exposed here show the usual lack of continuity in the bedding of these deposits. The shales and sandstones replace one another horizontally, and tongues of sand are frequently seen in thick shale beds (Plate XXIV).

The colour of the sandstones is yellow to light grey, they are mostly soft and friable some of the beds are merely sands with a soft clay matrix No sandstone beds hard enough to be used as building stones were observed in this district.

The shales are all of the soft, easily weathered variety, mostly of dull colours. Small ironstone concretions, either in layers or scattered through the beds, are frequent, but they are generally free from particles of gypsum.

Gwynne Station, Alta. A sample was taken from a shale bank about 1½ miles west of Gwynne station. The bank was about 25 feet in height, and except for a 2 foot bed of sand was all composed of soft olive shale. There was from one to two feet of overburden (Plate XXV).

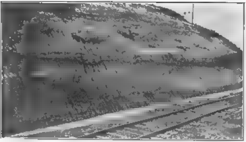
The sample was taken from the western end of the outcrop, below the sand bed, and represents an average of a 15 foot face of shale. This shale (1800) when mixed with 25 per cent of water formed a very plastic sticky mass of poor-working quality, which cracked in drying. Its air shrinkage was 8.5 per cent, and tensile strength 232 pounds per square inch.

It burns to a red brick, almost steel hard at cone 010, with a fire shrinkage of 1.4 per cent, and an absorption of 10.6 per cent. The clay softens at cone 1. Unless burned very slowly, this clay develops a black core, bloats and cracks the bricklets, so that it was not possible to burn it higher than cone 010 in our test kiln. This trouble is probably due to the presence of carbonaceous matter, but the amount is small, a chemical analysis specially made for this purpose showing only 0.88 per cent of organic carbon. The reason that this small amount of carbon causes such trouble in this case may be owing to the soap-like texture of the clay, so that the gases developed in burning off the carbon cannot escape from the body faster than vitrification of the surface of the brick proceeds, unless a great deal of time is consumed in the oxidation stage of the burning.

A portion of this clay was preheated in the laboratory to a temperature of 550° C. for 15 minutes. After tempering with water and moulding, the clay thus treated would stand fast drying. Exposure to this temperature was sufficient to drive off the carbonaceous content, so that bricklets then burned even in a comparatively short time to cone 03 showed no black coring or tendency to swell.

The preheated clay when wet-moulded dried with an air shrinkage of 3.6 per cent. After burning to cone 010, the fire

PLATE XXI



Shale with narrow sandy band. Edmonton series.
1 mile west of Gwynne, Alta.

PLATE XXII

Valley of Stony creek, 3 miles south of Camrose, Alta.

shrinkage was 0 7 per cent, and the absorption 19 per cent. At cone 03 the fire shrinkage was 9 per cent, and the absorption 10 9 per cent. Owing to the fact that this clay has a low fusing point and is not suitable for the manufacture of vitrified wares, the expense attending the preheating process for this particular case would not be justified, although there is a great quantity of the material that is easily accessible

Another sample was taken from a cutting on the railway line, about one mile east of Gwynne, representing a bed of soft grey shale about 13 feet in thickness, and without overburden.

This shale (1801) when mixed with 24 per cent of water forms a mass of fair plasticity, somewhat sticky, and containing so much fine grit that it may be described as a silt.

Its air shrinkage is 8 per cent, and the average tensile strength of the dry clay 140 pounds per square inch A full-sized brick cracks in drying, but the small test pieces did not.

This material makes a good red brick, almost steel hard at cone 010, with a fire shrinkage of 1 3 per cent, and 14 5 per cent absorption. At cone 03 the body is almost vitrified, with a fire shrinkage of 5 3 per cent. The clay flows very smoothly through a die, but short lengths of 3 inch round pipe made from it cracked and warped while air drying.

The clay makes a smooth, hard dry-pressed brick of good red colour, having a fire shrinkage of 4 per cent with an absorption of 8 2 per cent at cone 05, but several fire cracks develop on burning.

On both sides of the bank from which this sample was taken, the outcrops show about 14 feet of sands overlying thinner shale beds, or shale and sand beds interstratified and unworkable. These outcrops occur near the top of the valley wall of Pipestone creek, but the beds are also exposed in some of the spurs that extend out into the valley below the level of the railway line (Plate XXV)

A short distance east of this point the railway leaves the valley and traverses the prairie level, so that no outcrops are seen except on the shores of Bittern lake, until the town of Camrose is reached.

Camrose, Alta.—In the valley of the small stream which flows through the town, a bed of grey sandy clay has been partly uncovered. A sample of this clay was taken from a shallow pit about 3 feet deep, near the cement block works of Mr. J. O. Williams, but the thickness of the bed is unknown.

The clay (1795) is very gritty, and highly calcareous, but not sufficiently so to burn to a buff colour. Fifty per cent is held on a 200 mesh sieve. Mixed with 25 per cent of water it has a medium to low plasticity. The air shrinkage is 6 per cent and the average tensile strength when air dried is 144 pounds per square inch.

It burns without any fire shrinkage to a pale-red colour at cone 010, and with an absorption of 15.8 per cent. At cone 03 the surface of the bricklet is steel hard, the fire shrinkage slight, and the absorption 13.4 per cent. If raised to a slightly higher temperature this material softens rather suddenly and fuses completely at cone 1. The clay flows rather smoothly through a die from a stiff-mud machine so that it could probably be used to make wire-cut bricks and porous drain tile, moreover it can be dried moderately fast without cracking.

The shales and clays have been encountered at a few places under the overlying drift while opening up drains for pipe laying. At one point a deposit of greenish-yellow clay resembling axle grease and known as *bentonite* or soap clay was uncovered. This material, which contains 21 per cent of hydrous silica, is very fine textured, and has unusual absorbent qualities. Although considerably more refractory than any of the clays with which it is here associated, it contains too high a percentage of fluxing impurities to be a fireclay. The shrinkage and cracking of this material in drying is excessive. An attempt was made to use it in connexion with sand, and a bricklet made of a mixture of one part bentonite and three parts sand was burned to cone 03. It produced a soft-red brick with a total shrinkage of 3.5 per cent, and an absorption of 20 per cent, but was so weak as to be useless for structural purposes. Mr. M. A. Maxwell, the city engineer of Camrose supplied the following data of some borings made for the water supply, the descriptions

of the deposits passed through being taken from the drillers log.

Borehole No 1.		Borehole No. 2	
Clay	60 feet	Clay	12 feet
Shale.	10 "	Quicksand	27 "
Sandstone.	30 "	Shale	30 "
Coal.	4 "	Sandstone..	30 "
Black shale	50 "	Black shale	12 "
Sandstone*	10 "	Sandstone*..	10 "
Shale	31 "	Coal	4 "
Sand	10 "	Shale	5 "
Shale	40 "		130 "
Sandstone	10 "		
Shale.	10 "		
Coal and black shale	10 "		
Shale	5 "		
	280 "		

*Water best flow

The Vegreville-Calgary branch of the Canadian Northern railway approaches the town of Camrose from the south through the valley of Stony creek (Plate XXVI), and the fresh cuttings made at intervals along this line of railway afford several good sections of the Edmonton series. A sample was taken from one of the cuttings about 3 miles south of the town The section at this point consists of rather thin, alternating beds of sands, clays, shales, and lignites, having a total thickness of over 50 feet (Plate XXVII) There are three seams of lignite, separated from each other by several feet of shales, towards the bottom of the section A sample was taken representing the beds above the upper lignite seam, none of them being thick enough to mine separately Portions of thin layers of small ironstone concretions are included

This clay (1796) when mixed with 29 per cent of water forms a smooth sticky mass, with bad working qualities and abnormal cracking in drying. Its air shrinkage is 8 8 per cent, and tensile strength 120 pounds per square inch

Its fire shrinkage at cone 010 is 1 per cent, absorption 14 6 per cent, and colour red.

The bricklets are steel-hard when burned to cone 03, with a fire shrinkage of 5 8 per cent, and absorption of 3 6 per cent.

The clay vitrifies at cone 1, and softens at cone 3

It appears to contain soluble salts and the colour of the wet-moulded bricklets is not very clear

Dry pressed and burned to cone 05 this clay makes a facing brick of reddish-brown colour, with an absorption of 6 3 per cent At cone 03 the colour of the bricklets is dark red, with a steel hard surface, the absorption 4 6 per cent, and fire shrinkage 6 5 per cent A small sample from a bed of yellowish shale several feet in thickness, lying between the two lower lignite seams in the same section, was tested and the following results obtained.

This clay (1797) mixed up with 26 per cent of water to a very stiff dense mass, which could not be easily worked by wet-moulded processes, and cracked in drying. Its air shrinkage was 7 per cent.

Burned to cone 010 it produced a hard-red brick with no appreciable fire shrinkage and an absorption of 16 2 per cent At cone 03 the bricklets were steel hard, the fire shrinkage high, i.e , 8 3 per cent, and the body dense. It is completely fused at cone 1.

A bed of dark-brown shale lying under the lower lignite seam, and almost on a level with the railway tracks, also cracks while drying A sample (1790) from this bed had an air shrinkage of 5 6 per cent, and burned to a steel hard, red brick at cone 010 with 10 7 per cent absorption. The body is dense, with 9 6 per cent shrinkage at cone 03, and the shale fuses at cone 3

Beds of shales and clays of similar character to these are exposed at various parts of the valley between this point and Camrose, and samples of them would probably give a repetition of results outlined above At one point a bed of about 2 or 3 feet in thickness of bentonite was observed outcropping about 10 feet below the railway line. The extremely slippery character of this clay on which the railway track rests, probably accounts for the continual sliding of the latter into the valley bottom. A row of heavy piling now keeps the line in place.

The Edmonton-Calgary branch of the Grand Trunk Pacific railway was examined for some distance As this line runs on the prairie level, and mostly avoids the valleys, the light

cuttings along it show principally drift materials composed of sand and gravel. Some shales were seen close to this line, in a small stream valley near Dinart siding, 8 miles north of Camrose.

A sample of soft-yellow shales from the north side of this valley cracked so badly in drying that it was not tested further in the laboratory, but it is similar to No 1800 in character. A fair, reddish, dry-pressed brick was made from it which had a fire shrinkage of 2 5 per cent, and absorption of 14 per cent at cone 05, the brick, however, was somewhat fire checked.

On the south side of this valley a bed of harder shales was observed overlying a seam of lignite. This shale (1799) was very stiff and sticky when tempered with water, and the small test pieces cracked in drying. Its air shrinkage was 7 5 per cent, and gave a steel-hard light-red bricklet at cone 010, with a fire shrinkage of 1 per cent, and absorption of 12 5 per cent. At cone 03 the fire shrinkage was 7 5 per cent, and absorption 4 per cent. The shale softens at cone 1, and is completely fused at cone 2.

The lignite seam below this shale is mined to a limited extent by Mr H S Nomeland, on whose property it occurs.

The shales and clays, then of the Edmonton series, which occur in the neighbourhood of Camrose, do not seem to be promising materials for the manufacture of clay products. As the present examination, however, was not exhaustive it is quite possible that other clays may be found which will give better results

This statement is made, because, as already pointed out, the individual beds of this formation are not continuous over extensive areas and the character of the clay or shale may change from place to place.

The clays and shales are generally found well situated with regard to economy of working, and the transportation facilities of the district are excellent either for the assembling of raw materials at a central plant, or for the distribution of the finished product.

The lignite seams of the district, although thin, have been mined for some time near the town of Camrose, and a sufficient supply for burning clay wares could always be provided.

The results of some experiments made in the laboratory with a view to treating those clays which cause trouble in drying to make them workable, are given in another chapter

The preheating of the raw clay before manufacturing seems to be the best method for eliminating air cracks, the expense, however, of this process must of necessity preclude its application to any but the better grades of clay Preheating, therefore does not seem to be warranted for use with the clays thus far discovered in the Camrose district. The softening point of most of these clays is too low, cone 03 being about the limit to which they could be burned commercially They will not produce vitrified wares, or those varieties which require salt glazing, but No 1796 could probably be used for fireproofing, if commercial conditions would allow of the preheating treatment

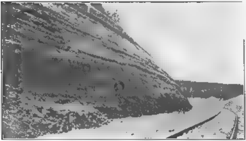
One per cent of salt was added to the clays which were moulded into test pieces This was found quite effectual for preventing the small pieces from cracking, but cannot be relied on to do so when the clay is made up into full-sized bricks, nor was the objectionable stickiness of the clays overcome by this means.

Some of the clays appear to give good results when dry-pressed, and other beds from which small samples only were taken, and not tested for dry-pressed bricks, may be adapted to this process also, and give a wider range of colour The bricks made by dry-press machines, however must be burned hard enough, at least to cone 05, and in some cases to cone 03. In order to accomplish this proper kilns must be provided for burning them Failure to produce good dry-pressed bricks in this region is due no doubt largely to the fact that they are fired in scove kilns and hence are not burned hard enough.

It is possible that losses by fire checking may run rather high, when some of these clays made by the dry press method are burned commercially This has been overcome to a certain extent at one plant in the west, by putting the clay as it comes from the bank through a rotary drier

Mitford, Alberta Previous reference has been made to the Tertiary shales outcropping along the Bow river between Cochrane and Kananaskis. These are usually dark in colour,

PLATE XXVII



Alternating beds of clay, sands and lignite on Canadian Northern railway 3 miles south of Camrose, Alta.

PLATE XXVIII

Shale outcrop at Milford, Alta.

much folded, and at many points show layers of hard sandstone or sandy shales.

The softest shales observed were those along the Canadian Pacific tracks west of the section house at Mitford.

Here there is an embankment (Plate XXVIII) just west of the coal mine, which is mostly soft shale, but shows much sandstone at the west end of the cut bank. The dip of the shale is obscure, but the sandstone at the west end of the bank dips eastward.

At one part of the bank there is a face of shale free from sandstone, at least 60 feet long and 30 feet high, and this was sampled for testing in the laboratory, with very satisfactory results.

The material (1760) is a non-calcareous shale, containing much coarse grit. It worked up with 17 per cent of water to a mass of medium plasticity, whose average air shrinkage was 5 per cent, and average tensile strength when air dried, 203 pounds per square inch.

The clay flows easily and smoothly through an annular die, and a full sized brick can be dried moderately fast without cracking

Wet-moulded bricklets yielded the following results on firing.

Cone.	Fire shrinkage.	Absorption.
	%	%
010	1	11·1
05	2	10·8
03	3·6	9·1
1	5	3·1
3	Fused	

This shale gives a good red hard body even at cone 010. The material is one of the best red-burning shales of the Great Plains, and while it would work for red brick and probably fireproofing, it is hardly refractory enough to stand salt glazing. Consequently we do not recommend it for sewer-pipe.

A dry-pressed brick at cone 05 had a good red colour, 3 per cent fire shrinkage, and 8·9 per cent absorption. This test

was very satisfactory At cone 1 the dry-press brick, although quite dense, was of too dark a colour.

Samples of the clay expressed through a 3 inch annular die gave good pipe at cones 010, 08, and 03.

About one-half mile west of the cut from which this sample was taken, there is another section of easterly dipping shales, with interbedded sandstones, but the thickest bed here is not more than 15 feet.

Tertiary Formations

These overlie the beds of the Edmonton series, and form a broad belt extending from somewhat north of the Grand Trunk Pacific railway west of Edmonton, southward almost to the International Boundary.

The most important occurrences are in the Calgary region, and those at Sandstone and Brickburn were referred to in last year's report.

Tests of the shales worked for brick at both of these localities were also given, and their comparatively low fusing point (cone 1) was noted

A description and tests were also given of a bed of shale, not utilized, located about one mile east of Cochrane.

The one caution that was sounded last year was that careful prospecting should be done before opening up any of these deposits, in order to find a section in which the sandstone beds were at a minimum

Nothing final was predicted at that time regarding the possibility of finding more refractory clays in this group of beds

Brickburn, Alta. At Brickburn the shale being worked for brick manufacture lies near the top of the escarpment overlooking the Bow River valley but no cuts had been made lower down in the section

It was known, however, that shales were exposed in the escarpment to the east of Brickburn, and further prospecting was strongly advocated

During the past year some work has been done on the tract just east of the brickworks, showing that the shale beds probably continue down to the track level The shales were also found

outcropping in the gully extending southward from the track and leading to a sandstone quarry, which appears to lie higher than the Brickburn clay pit.

On the face of the escarpment two openings were made. One of these was perhaps 50 feet above the track level, and showed several beds of shale 3 to 4 feet in thickness, interstratified with several beds of sandstone.

Another opening had been made about 25 feet higher up the bank, and here a soft shale was exposed, but the face of the excavation was not more than 6 feet high. There was no evidence of sandstone outcropping in the slope above the excavation.

A car load of shale had been shipped from this cut to the sewer-pipe plant at Medicine Hat in order to test it for the manufacture of sewer-pipe, and the results of this test are said to have been satisfactory.

A sample for testing was also taken by us from this same excavation and the results are given below.

The material (1759) worked up with 18 per cent of water to a mass of good plasticity but containing much fine grit. Its average air shrinkage was 6 per cent, and full-sized bricks could be dried moderately fast without cracking. The average tensile strength when air dried was 60 pounds per square inch.

Burning tests of the wet-moulded bricklets were as follows:—

Cone	Fire shrinkage.	Absorption	Colour
	%	%	
010	0	13·2	Light red
05	0·7	11·0	" "
03	3	8·1	Red
1	3·4	6·7	"
3	3·6	4·5	"
5	4	4·5	Dark red
9	Vitrified		
15	Fused		

These results show that the clay has low fire shrinkage, low absorption, and burns to a good colour. It should not only make a good brick, but commends itself also for fireproofing and sewer-pipe. Indeed trials made of this clay at the sewer-pipe works at Medicine Hat show that it takes a good salt glaze.

Of great significance is the fact that this shale occurs close to that worked for brick at Brickburn, Alta., but the bed is at a

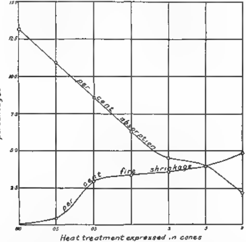


Fig. 5.—Absorption and fire shrinkage curves of sewer-pipe shale No. 1759, from Brickburn, Alta.

slightly lower level. The brickworks shale fuses at cone 1, while this is only vitrified at cone 9.

We have here then two shales of widely different properties occurring close together in the same formation, and which emphasizes the point made by us in last year's report, viz., that these Tertiary shales occurring south and west of Calgary should be carefully exploited.

Unfortunately the bed-rock is covered at most places, if only by surface wash from the upper slopes, but if these are trenched the shale can no doubt be found at many points without much difficulty. Such examinations should be made in the valley between Calgary and Cochrane.

CHAPTER V.

Mountain Region.

This includes the region bordered on the east by the Great Plains and on the west by the Coast range, and has not yet been shown to have extensive clay resources. Moreover, as already pointed out, those which may occur in this region cannot be of much commercial value unless situated close to lines of transportation.

In Memoir 24-E, containing the results of last year's work, we divided the clay resources into two classes, viz., shales and surface clays, neither of which was of very great importance.

Such a grouping hardly seems warranted in the present instance, and, therefore, the localities will be referred to going from east to west.

Blairmore, Alta. Reference was made in our last report to the Kootanie shale which is being worked at Blairmore for the manufacture of dry-pressed brick, but no tests of the material were given. The plant was still in operation in 1911, but the shale gives considerable trouble with black coring, evidently due to too rapid firing of the clay. There is also danger of getting the arches overburned, and not getting enough fire in the middle and upper benches of the kiln.

In order to overcome some of these difficulties the kilns, which are simply permanent side wall structures, were being made narrower.

A sample (1766) representing the run of the bank was tested by us in the laboratory. We found it to be so gritty and of such low plasticity that it could not be wet-moulded, and we consequently formed it into dry-press bricklets.

Owing to the carbonaceous matter in the clay it had to be

burned very slowly, until all the carbon was driven off The following results were obtainable:—

Cone.	Fire shrinkage.	Absorption.	Colour
	%	%	
05	2·5	7·5	Red
1		4·4	"
2	Fused.		

The clay should be burned to cone 05 to give a good hard brick, and this heat is probably not being reached in the kilns at the yard

Frank, Alta —An attempt was made to determine whether there were any shales in the vicinity of Frank that might do for brick making On the western edge of the slide, and along a wagon road leading up over the same, there are outcroppings of shale, while farther up the hill, the conglomerate is exposed. Across a small gulch to the west there is a shale which overlies sandstone.

Back of this is another valley which may represent a fault line, and to the west of this is a high limestone ridge.

The material here (1767) is a hard, rather splintery grey shale, which is not plastic when ground. It does not vitrify at cone 1, but fuses at cone 2.

Two dry-press mixtures were tried, one at cone 05 and the other at cone 03. Their fire shrinkage was 2·5 in each case, and the absorption was between 5 and 6 per cent.

The shale burned to a deep red and was easier to fire than the Blairmore brick shale since it probably contains less carbonaceous matter

Coleman, Alta The same shales also outcrop along the wagon road about one mile east of Coleman, and while the material is gritty, it did not look so unpromising as some of the others in this region. We, therefore, tested a sample of it (1768) but found that even when finely ground it had low plasticity

It was possible with care to make wet-moulded bricklets, and it was more plastic than the Frank or Blairmore samples.

The average air shrinkage of these was 4 per cent. They gave the following tests on burning.

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	Slightly swelled.	13·6	
05	0·4	12·0	
03	3·4	7·6	
1	Softening.		
2	Fused		

This clay is a somewhat unsatisfactory one and hardly to be recommended, although it could be used for common brick.

Fernie, B.C.—Common cream coloured bricks have been made from a surface clay at this point, but they are chiefly for local consumption. A great interest centres in the shales which outcrop along Coal Creek canyon, between Fernie and the mines, consequently a number of these outcrops extending up the valley to the Cold Creek mines were examined with some care. In every instance the shale which was interbedded with sandstones was found to be exceedingly gritty and not adapted to brick making.

Morrissey, B.C.—The Crowsnest Pass Coal Company has a branch road extending from the Great Northern railway up the valley at Morrissey, to which point mines in the past have been in operation. There are a number of shale outcrops along the track, but all of the material is exceedingly gritty and unsuited for the manufacture of brick. Moreover, none of it seems to be refractory in character.

It is also interesting to note that there are no soft underclays below the coals at either Morrissey or Fernie.

Only one sample was tested from the Morrissey district, and this was collected from the first cut up the branch line to Morrissey.

It (1771) is a very gritty, grey, calcareous shale, of such low plasticity that it could not be wet moulded.

A dry-press bricklet burned to a buff colour at cone 05, with an absorption of 22 9 per cent and no fire shrinkage. It fuses at cone 4.

Although the material makes an attractive looking brick, the use of this shale is not recommended.

Several additional samples of shale from the Fernie region were subsequently submitted by Mr. Wilson of the Crowsnest Pass Coal Company. They were —

Hard dark grey shale, marked No. 1 (1781).

This is calcareous and of very low plasticity, so that it was very difficult to mould wet. Some bricklets were wet-moulded for burning and gave a dull-red body, which was not steel hard even at cone 05. At cone 010 the bricklet was slightly swelled and had an absorption of 16 7 per cent. At cone 05 the fire shrinkage was 0·3 per cent, and the absorption 15 6 per cent.

The shale is not to be recommended.

A dark coloured shale, marked No 3 (1782), is practically the same as the preceding.

A hard dark grey shale, marked No. 4 (1783), was of very low plasticity, and so was moulded dry-press. These dry-press bricklets were burned at two temperatures.

At cone 1 the bricklet was grey with 0 per cent fire shrinkage and 10 per cent absorption. At cone 5 the fire shrinkage was 0 per cent, and absorption 9 5 per cent. The bricklet had swelled a little at cone 9, but was still unaffected at cone 15 and white in colour

Elko, B.C. In our last year's report attention was called to a talcose schist which was said to come from Fernie. Further investigation develops the fact that the material really occurs along the government road 9 miles south of Elko, and along the line of the Great Northern railway It is found there in several nearly vertical bands, which are closely associated with quartzite,

Active attempts have been made for a number of months to exploit this material as a fireclay, but it is not such, and indeed

it is not even refractory in its nature, for a sample of it was tested by us, as mentioned in last year's report.

Golden, B.C. Golden lies in the Columbia River valley, and along the main line of the Canadian Pacific railway. The river itself is bordered by flat lands, some of which are covered by a slight rise in the stream level. On the east side of the valley there is a ridge of low hills, made up apparently largely of glacial material, and containing pockets of tough bluish clay, which weathers to yellow, and is very silty in its character. It also seems to be quite calcareous in its nature, as shown by the tests given below. It was not tested, not because it was not thought to have any economic value, but for the reason that there was not enough of it.

Underlying the river flats there is in places considerable silty clay of flood-plain origin. Some of it is very plastic, sticky material, while at other times it is very sandy. Its exact depth is unknown. While it is probable that this flood-plain material could be used for the manufacture of bricks, still owing to the highly calcareous nature of the deposit, the product would be exceedingly porous.

There is a possibility that it could be formed into cheap pottery by a casting process, but it is not sufficiently plastic for throwing on a potters wheel. Experiments made by us show that not only can it be cast into porous pottery ware, but it will also take a white tin glaze.

At the present time such bricks as are used at Golden are brought chiefly from Cochrane west of Calgary, and it may be mentioned that the clay at Cochrane is in many respects not unlike that which occurs at Golden, but is somewhat more plastic.

Common bricks are made at Windermere, farther down the Columbia valley, but they are said to be quite porous.

The results of our laboratory tests on the Golden clay (1769) are given below.

It is a highly calcareous, yellowish silty clay, which worked up with 32 per cent of water to a mass of only moderately plastic character, and hardly coherent enough to work in any but a soft-mud brick machine.

The average tensile strength was 50 pounds per square inch, and the average air shrinkage 4·5 per cent.

The results obtained on firing are given below —

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	Slightly swelled	42·6	Buff
05	" "	42·6	Cream.
03	" "	45·2	"
1	Past vitrification		
2	Fused		

This clay burns to an exceedingly porous body, and softens rapidly as its point of fusion is approached. It could be used for cheap majolica, and common brick.

The deposit is favourably located for working.

Kamloops, B.C.—A sample of clay was submitted by W. R. Austin, of Kamloops, B.C., which was taken from the S. W. ¼. of section 3, township 20, west of the 6th Meridian. This material was yellow in colour, slightly calcareous, and very gritty. It was evidently a surface clay, for it contained some decayed plant stems. This clay when tempered with water formed an exceedingly stiff waxy mass, which was very hard to mould. The wet moulded bricklets cracked badly in drying. Some of the clay was dry-pressed and burned slowly to cone 010. The dry-pressed bricklet cracked so badly in firing that it was useless. It would be futile to attempt to utilize this material in the manufacture of clay products.

Nicola Valley, B.C.—This valley lies in the Yale district of British Columbia. It is reached by a branch of the Canadian Pacific railway, running southward from Spences Bridge and terminating at Nicola.

The valley between Spences Bridge and Merritt is somewhat narrow (Plate XXX), but between the latter place and Nicola it widens considerably.

View of valley at Morrissey, B.C.
The hard siliceous shales outcrop along the railway track

Plate XXX

View of Nicola valley at Merritt, B.C.

The ridges which wall in the valley are of Tertiary volcanic rocks, and in the trough formed by these lie the Coal Measures which are of Oligocene age.

Camsell in a paper on the mineral resources of Yale, B.C.,[1] says:—

"Oligocene rocks occur in several small isolated basins throughout this region. The rocks in these basins consist of sandstones, shales, conglomerate, and coal. Such basins are situated at Princeton, Granite Creek, Nicola, Quilchena, Kamloops, Enderby, Nicoamen, Okanagan Lake, and White Lake. Each of these Oligocene basins contains some coal, and most of them contain several workable seams. * * * The Nicola coal basin lies in the valley of the Nicola river and extends from the lower end of Nicola lake for 14 or 15 miles to the mouth of Guichon or Ten Mile creek. The maximum width of this portion is about 3 miles. The same basin then extends northward up Guichon creek for about 7 miles, and here has a width of nearly 3 miles. The rocks dip in many directions, and at various angles and some faults may occur. Five different seams are being worked, varying in thickness from 6 feet to 18 feet 6 inches. The coal is bituminous and yields a firm coherent coke."

In the Nicola valley the coal is being worked around Merritt, and the measures there are bent into a series of folds with dips ranging from 25° to perhaps 40°.

There are at least three seams of coal, which are interbedded with sandstones, sandy shales, and some conglomerate.

Two samples were collected for testing, both of these being from the slopes of the Inland Coal and Coke Company. This Company's openings are on the slope above those of the Nicola Valley Coal Company. The beds dip about 25° east of south, and are overlain and underlain by shales.

One sample collected (1774) was a grey shale from the roof of the No. 1 seam. Only 4 feet of the shale bed was exposed, but it is claimed to have a thickness of 20 feet. It worked up with 22 per cent of water to a mass of rather fair plasticity, but containing somewhat coarse grit. The average air shrinkage was 5 per cent.

[1] Quart. Bull. Min. Inst., No. 12, 1910.

Wet-moulded bricklets behaved as follows in burning —

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	2·4	13·8	Light pink.
05	4·3	7·0	"
03	5·7	5·4	"
1	6·0	2·6	"
3	6·0	2·6	"
5	6·3	2·4	Grey
9	Vitrified		
13	Still vitrified		

This clay commends itself. The air and fire shrinkage are not excessive, and the absorption is low. The fact that the

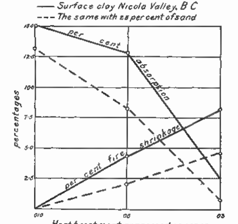
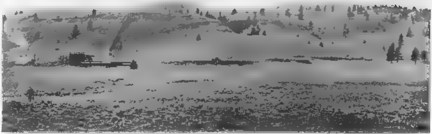


FIG. 6.—Absorption and fire shrinkage curves of surface clay from Nicola valley B.C.

clay is only vitrified at cone 13, suggests the possibility of utilizing this clay for boiler brick, or special shapes for coke oven trimmings, for it stands more heat than the coke oven trimming bricks used at Coleman, which fuse at cone 9.



3553 (p. 7) View of west side of valley at Merritt, B.C. At left is the surface plant of Nicola Valley Coal Co.

A second sample was taken from the floor of No. 3 seam, and where exposed averaged only 10 inches in thickness, but there is a possibility that it may thicken up.

This material (1775) is a nice smooth plastic shale, but the main objection to it is that it cracks even in slow air drying.

Wet-moulded bricklets were made up and burned. Their behaviour is cited below:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
010	8·3	23·30	Salmon.
05	5·0	10·4	"
03	7·0	5·4	Red.
1	8·3	2·0	Brown.
5	Not fused		

This clay burns to a good brick body of fairly low absorption at cone 05, but the objection to it is the air cracking.

It is of far less value than the preceding.

A rather hard, tough, greyish-brown shale was struck in some quantity in a new drift being driven by the Nicola Valley Coal Company, and although it does not look very promising, still it grinds up to a very plastic mass. Its refractory qualities are not known.

The Diamond Vale colliery has a slope driven on the eastern edge of a syncline which dips under the south side of the valley.

The rocks associated with the coal are chiefly sandstones and much slickensided carbonaceous shale, hence they offer nothing that is attractive to the clay workers.

On the Triangle ranch near Quilchena, we found some outcrops of coaly shale and *bentonite*. These outcrop on the lower slopes on the west side of a north south valley, which is rimmed in by volcanic rocks. The coal measures strike N. 10° E., and dip 30° S E., and at a point where an opening was made in search of coal the limited section shows:—

Coaly shale	
Concealed	10 ft.
Bentonite	3 ft.
White clay, probably dried bentonite.	6 ft.
Coaly shale.	6 ft.
Concealed	

The bentonite[1] is dense, with a greasy look and conchoidal fracture. The bed below it is similar in structure but is white and chalky looking, and is probably the same material which has dried out on exposure to the sun.

The bentonite has strong absorbent properties, and this particular sample required a high amount of water to work it up into a plastic mass. It is of no value for brick making.

As an experiment a sample of it was mixed with sand in the proportion of 1 to 3, and gave a fair bricklet whose air shrinkage was 5 per cent. The fire shrinkage at cone 010 was 0 and the absorption 14.4 per cent. It burned light red.

The white clay occurring under the bentonite (1776), forms a very stiff plastic mass of soap-like character when wet, and cracks badly in air drying. It, therefore, behaves similarly to the bentonite.

The air shrinkage is high, viz., 12.3 per cent, and the clay is not of commercial value for the manufacture of clay products. It may be remarked, however, that at cone 5 it burned to a body whose absorption was 5.9 per cent, but is not fused at cone 15.

Bentonite has been used in the manufacture of soap, as a packing for horses' hoofs, as a diluent for certain powerful drugs sold in powdered form, and as an adulterant of candy. It is also said to have been used in the manufacture of antiphlogistine, and makes a good retarder for cement plasters. Its chief use perhaps has been for filling paper.

The most extensive clay deposit in the Nicola valley is a stratified surface clay which occupies a terrace found at many points in the valley. It is evidently a lake deposit, which was laid down in the valley at some former period when the drainage was obstructed by natural means so that a lake of some size resulted.

Into this lake there was washed a great quantity of fine-grained silty clay. Removal of the dam which held in the lake waters has allowed the stream occupying its present level to cut away much of the clay deposit.

[1] For further information on this type of clay see Ries, Clays, Occurrences, Properties, and Uses, 2nd Ed., Wiley & Sons, New York.

Section in [illegible] between Merritt and Nicola.

Slide of lake clay in Nicola valley between Merritt and Nicola.

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Good exposures of the clay are to be seen by the bridge on the southwestern edge of the town of Merritt, also northeast of Merritt on the road to Nicola, in the railway cut near the Diamond Vale Colliery, and at several points along the wagon road from Merritt to Nicola (Plates XXXII and XXXIII).

As this clay is undoubtedly of some economic importance, a sample of it (1779) was tested in some detail. These tests showed it to be a calcareous clay containing occasional small scales of gypsum and much fine grit. It worked up with 29 per cent of water to a mass of excellent plasticity whose average air shrinkage was 10·0 per cent, and whose tensile strength when air dried was 412 pounds per square inch. Both of these are high, and on account of the high air shrinkage the clay should be mixed with sand. The addition of 25 per cent of this reduced the air shrinkage to 8·5 per cent.

Two lots were wet-moulded and tested in the fire. The results of this are given below, A being the clay alone, and B the clay with 25 per cent sand.

	A	B
Cone 010—		
Fire shrinkage.	0	0·3
Absorption	15·2	13·8
Colour	Light red	Red
Cone 05—		
Fire shrinkage	4·5	2
Absorption.	13	8·6
Colour	Light red	Red
Cone 03—		
Fire shrinkage	8	
Absorption	2·2	
Colour	Red	
Cone 1	Fused	

A dry-press bricklet of the straight clay gave an excellent hard brick of red colour at cone 05, whose absorption was 10·3 per cent and whose fire shrinkage was 6·5 per cent.

The clay is very smooth and flows through an annular die. If the clay alone was treated in this manner it showed a tendency to tear slightly in issuing from the die, but a mixture of the clay and 25 per cent of sand did not give this trouble. The clay should work for common and dry-press red brick, and drain tile, but some sand must be added to it.

CHAPTER VI.

Pacific Coast Region.

Clayburn, B C. In our report of last year we discussed at some length the important series of shale deposits found in Sumas mountain, near Clayburn.

At that time the Clayburn Company was working a fire-clay deposit at the end of its narrow-gauge railway, but using the mixture of clay above and below the coal parting.

Since then the mining operations have been restricted chiefly to the clay underlying this coal parting, and a sample of this was tried in the laboratory.

The material (1789) is a hard dark-grey clay, which worked up with 15 per cent of water to a mass of only moderate plasticity whose average air shrinkage was 3 per cent, and average tensile strength when air dried 65 pounds per square inch.

The firing tests on these wet-moulded bricks yielded:—

Cone.	Fire shrinkage.	Absorption.	Colour
	%	%	
1	1·3	9·8	Cream.
3	2·0	9·7	"
5	2·0	10·0	Buff
9	3·0	8·5	"
30	Fusing point		

This clay shows low fire shrinkage and moderate absorption. It burns to a good firebrick body.

Associated with the coal seam is a shaly parting of somewhat flinty clay (1788) which is feebly plastic, and has a low air shrinkage, viz., 3·5 per cent. Owing to its refractory

View looking up [illegible] showing entrance [illegible] which supplies the [illegible] for buff [illegible] section shown [illegible] Plate XXXV is on the left side of track

[illegible] ra' way of Clayburn Brick Co. Clayburn, B.C.
[illegible] ning shale
lain by sandstone and conglomerate

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character it was not burned below cone 1. The firing tests are as below:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
1	4·6	8·2	Cream
5	6·0	8·0	Buff
9	5·7	7·1	"
33	Nearly fused		

This is a good grade of fireclay, and could be utilized in the manufacture of firebrick, but should have a small proportion of plastic clay mixed with it.

Underlying the lower fireclay is a so-called *china-clay* which was referred to in last year's memoir.

Since writing that report a sample of this clay was ground to pass through a 10 mesh sieve, and then put through a washing process. This gave 18 per cent of fine clayey material, the residue being mostly rounded sand grains coated with clay and a film of hydrous iron oxide.

The washed product was very smooth and plastic, and had an air shrinkage of 6·5 per cent. In burning we got the following results:—

Cone.	Fire shrinkage.	Absorption.	Colour.
	%	%	
1	5	13·2	Pinkish white
5	7·6	9·8	Light drab
9	7·5	5·2	"

This gave a nice smooth body, and although not as white as a china-clay still it could probably be used in a pottery or wall-tile body. The only objection to it is the small percentage of washed product obtained.

Nanaimo, Vancouver Island.—The rocks of the upper Cretaceous or Nanaimo series as developed around Nanaimo,

consist of a series of conglomerates, shales, and sandstones, with some interbedded coal seams, the entire section as worked out by Mr C. H. Clapp being given below

The whole series dips gently to the eastward, with a few interrupting folds of subordinate value.

UPPER CRETACEOUS.

Nanaimo Series.		Thickness.		
—	Lithological character	Min.	Max	Average
Gabriola formation	Chiefly sandstones	1,400	1,400	1,400
Northumberland formation	Conglomerates, sandstones, and shales.	1,100	1,200	1,150
DeCourcy formation	Chiefly sandstones	300	1,400	850
Cedar District formation	Chiefly shales.	700	1,000	750
Protection formation.	Chiefly sandstones, coarse gritty sandstones.	600	750	650
Newcastle formation (Douglas coal seam)	Fine conglomerates and sandy shales, and contains Douglas seam	160	400	200
Newcastle coal seam				
Cranberry formation	Flaggy and shaly sandstones and sandy shales, and gritty sandstones and fine conglomerates.	150	500	250
Extension formation	Chiefly conglomerates, also shale and sandstone horizons and small coal seams	700	1,600	800
Wellington coal seam.				
East Wellington formation.	Sandstone	25	60	35
Haslam formation (Marine shales) (Departure Bay calcareenites,	Chiefly shales	500	600	600
Benson formation.	Basal conglomerate.	0	400	100
Total.		6,125	9,400	6,785

Most of the shale formations are hard and gritty, and not very promising in their appearance, but in view of the fact that

many of them are well located for working it was thought best to give several of them a laboratory test.

Cedar Shales.—These are found outcropping on the east bank of the Nanaimo river about one mile from its mouth.

The bank, which is about 20 feet high, shows bluish-grey shales, which weather down to angular particles, and not to a soft clay. Scattered concretions are found in the rock. The material is feebly plastic, and burns to a red colour. It could only be made into a dry-press bricklet with care, and fused at cone 1.

The same shale also outcrops on the west shore of the Canal de Haro.

This material (1784) is very gritty, and even when finely ground develops only feeble plasticity. Its average air shrinkage was 4 per cent, and it burns to a good red colour at cone 010, but is altogether too gritty for brick making.

Haslam Shales. These outcrop along the narrow-gauge railway on the hill above Extension. They are dark, fine-grained, gritty shales, not differing much in their character from the Cedar shales.

A sample (1786) was tested and found to be very feebly plastic so that it was wet moulded with difficulty. It could probably only be used successfully by having some more plastic clay added to it.

The air shrinkage, as might be expected, was low, viz., 6 per cent. In burning the wet-moulded bricklets behaved as follows:—

Cone	Fire shrinkage.	Absorption.	Colour
	%	%	
010	1·0	13·8	Red
05	2·0	10·4	Dark red
1	3·6	2·5	"
3	4·6	3·0	"
5	5·0	1·8	"

This shale burns to a good hard body nearly steel hard, cone 05, and gives a good red colour at cone 010. Above this,

however, it becomes too deep in colour for appearance. If the shale were only more plastic it could be recommended for fire-proofing and perhaps even paving brick.

The Haslam shales outcrop also at Wellington, B.C., and it is stated that they are to be utilized for brick and tile manufacture, in fact there were on exhibition in Nanaimo some hollow brick and stiff-mud brick which were said to have been made from these shales alone.

A sample of this shale (1780) was tried by us in the laboratory.

We found that it was feebly plastic if finely ground, but even so difficulty was experienced in wet-moulding it. Perhaps grinding in a wet pan might improve it. The average air shrinkage was 5 per cent.

The wet-moulded bricklets behaved as follows in burning:—

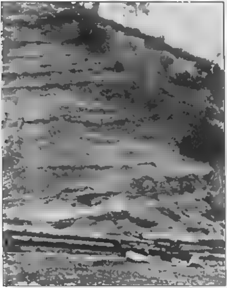
Cone.	Fire shrinkage.	Absorption.	Colour
	%	%	
010	1·0	10·5	
05	1·8	9·5	
03	3·8	8·7	
1	Past vitrification		
2	Fused		

It is unfortunate that this shale is not more plastic for it could undoubtedly be used for making brick and fireproofing. The addition of some red-burning surface clay would vastly improve it. A dry-press bricklet burned at cone 05 gave a good hard red body, with 3 per cent fire shrinkage, and 4·4 per cent absorption.

Northumberland Shales.—A small sample of this formation was collected from the outcrop on Descanso bay (Plate XXXVI), on the northwest end of Gabriola island.

The shales here represent the more shaly part of the Northumberland formation, and consist of alternating beds of gritty shales and sandstone, the layers of the latter being 2 to 12 inches thick

Plate XXXVI



[illegible]
Gabriola island, near Nanaimo, B.C.

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The shale passes into conglomerate on the strike, and is of the same formation as the shales outcropping on Mayne island.

A sample of the shale (1787) tested gave the following results —

It is a hard grey shale, which when mixed with 20 per cent water gave a mass of low plasticity It was more plastic, however, than 1776, 1780, 1874, or 1785, which are the other shales of this region. Its average air shrinkage was 4 per cent.

The wet-moulded bricklets were fired with the following results -

Cone.	Fire shrinkage.	Absorption.	Colour
	%	%	
010	0	14·6	Light red.
05	4	7 3	Red
03	8	1 0	Dark red.
1	Vitrified.		
3	Fused		

This shale burns to a good colour at both 010 and 05, and is nearly steel hard at the latter cone. Its shrinkage is not high, and neither is the absorption The clay if ground in a wet pan might be plastic enough to flow through a die.

Suquash, Vancouver Island.—During the autumn of 1911, Mr C H. Clapp visited the coal district of Suquash, and sent us from there two samples of Tertiary shale, which are considerably more plastic than anything we have seen from Vancouver island

The superiority of these shales over those of Nanaimo, at least as far as their plasticity and smoothness were concerned, impressed itself on Mr Clapp in the field.

One of the samples sent us was a dark grey, hard laminated shale, containing a very slight amount of calcareous matter and some films of carbonaceous material.

It worked up with 31 per cent of water to a fairly plastic mass, but no wet-moulded bricklets of it were burned as it showed a decided tendency to crack in drying.

The average tensile strength was 108 pounds per square inch

A dry-press bricklet burned at cone 05 was red in colour, nearly steel hard, and had a moderate absorption of 13 60 per cent.

The clay could probably be used for dry-press brick. It fuses at cone 3

The second sample was a light grey, non-calcareous clay, with scattered mica scales.

It worked up to a rather plastic mass, but took a large amount of water, viz, 40 per cent.

The average tensile strength was 95 pounds per square inch, and the average air shrinkage was very high, viz., 14 per cent. It also had the fault of cracking when dried fast. However, some wet-moulded bricklets were made of it, and burned at cones 010, 05, and 03.

The fire shrinkage at all these cones was close to 7 per cent, and the absorption 8 5 per cent.

The clay burned to a light buff It fused at cone 2.

A dry-press bricklet burned at cone 05 was barely steel hard, pinkish buff in colour and had an absorption of 12 10 per cent.

It can hardly be recommended as a desirable clay to work alone.

A mixture of equal parts of the two Suquash clays was next tried This gave a smooth plastic mass with 35 per cent of water, but it also showed a tendency to crack in drying.

A dry press brick of the mixture burned to a light red colour, with 18 12 per cent absorption at cone 05.

The objections then to the samples sent in are (1) high percentage of water required for mixing, (2) high air shrinkage; (3) tendency to crack in drying.

On the other hand it must be stated that they represent the smoothest and most plastic shales which we have seen from Vancouver island, and it is possible that a better mixture could be obtained from this locality.

CHAPTER VII.

Experiments in Preheating Clays.

J. Keele.

Among 120 samples of clays and shales collected during the seasons of 1910-11 in the Great Plains region, 28 of them or about 23 per cent cracked in air drying after being moulded.

These defective clays occur principally in the Belly River and Edmonton formations, and in the upper part of the Cretaceous, but some of the Laramie clays have the same fault.

These clays are frequently found in localities well situated for transportation, they are easily worked, and occur in great abundance. They would therefore, be of great economic importance if they could be utilized, as many of them will make fire-proofing, and some even can, we believe, be manufactured into sewer-pipe if their tendency to crack while drying can be overcome.

Several beds of these clays and shales could be manufactured into facing bricks by the dry-press method, but it is impossible to use them for the many important structural wares which involve the use of the wet-moulded processes.

During the progress of the laboratory work on the samples of these clays collected in the field, the writer was confronted with the difficulty of preparing test pieces from them for the purpose of observing their behaviour under fire. The clays absorbed a great deal of water in tempering, afterwards forming a stiff pasty mass which was tough and sticky and hard to work. Shortly after being set to dry the moulded shapes cracked, even small test pieces splitting badly in the ordinary laboratory temperature. The surface of a full-sized brick readily became dry, and developed a perfect network of cracks, which deepened and widened as drying progressed while the inside remained moist for several days. The use of substances which would coagulate the clay was tried to cure this cracking, being careful

to use materials which were cheap and readily available, so that if the remedy were successful it could be used on a commercial scale Of the various acids and alkalis tried, common salt to the amount of 1 per cent added to the clay seemed to give the best results The salt kept the surface of the bricklets moist while the water was working its way out of the body

Full-sized bricks made from some clays thus treated would dry safely in the ordinary room temperature, but many clays would not, and few of the salted clays would stand even moderately fast drying.

Furthermore the stickiness and soap-like qualities of the clays were not ameliorated to any appreciable extent by the mixture.

The next method which suggested itself was the use of non-plastic materials like sand or grog. River sand, ground quartz, and calcined clay were successively used. These were added to the clays in varying amounts up to 50 per cent.

The mixtures with sand failed in every respect, and although the grogged clay could be safely dried in some instances, and burned to a good body, the bad-working qualities of the raw clay were still in evidence.

Professor Orton,[1] who was experimenting on some clays of the Edmonton series at the same time as the writer, was unsuccessful in overcoming their drying defects by the use of either chemical coagulants, or additions of non-plastic materials.

There remained then the method described by Professor A. V. Bleininger for treating clays that cracked in drying, by preheating them at various temperatures.

Preheating experiments were done on several of our clays, and the results arrived at seem to prove that this is the best method so far, for dealing with the difficulty

The data for six samples of clay from localities widely apart are here given. Clays of these types may be expected to recur frequently in other localities throughout the region we are dealing with Numbers 1644 and 1755 are used for

[1] Edward Orton Jr Experiments on the drying of certain Tertiary clays, Trans. Am Cer Soc, Vol XIII

making dry-pressed bricks, but the other samples are from unused deposits.

1644. Dark grey massive clay, underlying a lignite seam, Estevan, Sask.

1755. Light grey massive clay, Coleridge, Alta.

1765. Dark grey soft shale, underlying a lignite seam, Tofield, Alta.

1675. Light grey hard shale, overlying coal seam, Oldman river, Alta.

1800. Soft olive shale, Gwynne, Alta.

1796. Soft shales interbedded with streaks of sand, Camrose, Alta.

The clays were heated in a small rotary drum, made of sheet iron, and having baffles projecting from the inside to keep the clay well stirred up and evenly heated.

A stationary sheet iron hood enveloped the drum except where openings were left for the gas flames to enter. The drum, which was revolved by hand, was provided with a hollow axle, through which a pyrometer tube was inserted. About one-half to three-fourths of an hour was generally taken to bring the clay to the required temperature, the latter being easily kept constant during the time allotted for treatment.

The length of time allowed at each temperature was 15 minutes, each clay being kept for this period at successively higher temperatures until it yielded to the treatment. Other trials were made of 30 minutes duration at certain temperatures, to show the effect of time.

The latter results show that it is possible to obtain effects at lower temperatures with increased time, similar to those given in the shorter time at higher temperatures, but this appears to be true only within certain limits, as Professor Orton's experiments show that some of these clays were not improved by exposure for 1½ hours to a temperature of 400° C. Steam was given off freely from the heated clay at all temperatures up to 500° C. The fumes evolved at higher temperatures smelled strongly of sulphur and hydrocarbons, which was probably due to the dissociation of particles of pyrite and driving off of bituminous matter.

When the heating was completed all the clays except No. 2 were much darker in colour than in the raw state, being dark grey to almost black

CLAYS HEATED IN ROTARY DRUM

No.	—	400° C. 15 min.	450° C 15 min.	500° C. 15 min.	500° C 20 min	550° C 15 min.	550° C 20 min
1644	Drying at 65° C " 30° C Plasticity				Bad Bad Good	Improved Good Fair	Good Good Low.
1755	Drying at 65° C " 30° C Plasticity	Good. Good. Fair					
1765	Drying at 65° C " 30° C Plasticity					Bad. Bad Good	Bad Good Fair
1675	Drying at 65° C " 30° C Plasticity					Bad Bad Good.	None.
1800	Drying at 68° C " 30° C Plasticity				Bad Bad Good	Improved Good Fair	None.
1796	Drying at 65° C " 30° C Plasticity		Bad Bad Good	None.			

Clay No. 1755 yielded at a comparatively low degree of heat treatment, probably due to its containing a relatively large amount of grains larger than clay substance than any other of the samples tested

The tenacity with which clay No 1765 clings to its plasticity under the action of heat is remarkable, as that property was not affected to any great extent even at the highest limits of the experiment It would no doubt succumb to a more prolonged exposure at 550°, or it might be successfully treated at 600° for fifteen minutes. The latter was not tried, however, as it is possible that the amount of preliminary heating that could be economically applied to this or similar clays in practice was already exceeded.

The results given by sample 1675 show the slight margin in time that exists between the proper and unsuccessful handling of some clays.

After the 30 minute treatment at 550° this clay was sandy in texture, and could not be moulded into shape, while after the 15 minute treatment its defective qualities were quite unimpaired

The precise time then for the clay at this temperature appears to be either 20 or 25 minutes, but, as will be explained later, the 30 minute treatment was not fatal.

The results of previous experience without any special apparatus, showed that the clays would require a high degree of heat treatment, but to avoid mistakes all the clays were heated to 350°C., however, since no change occurred in any sample at this temperature it is unnecessary to include it in the table.

The test pieces made up for the drying tests were 2½ inch cubes, as there was not a sufficient quantity of the various clays in stock to make full-sized bricks The cube, however, has a greater volume for the amount of surface than any of the brick shapes.

The driers used in the experiment consisted of small chambers attached to the steam heating apparatus of the building. The maximum temperature that could be obtained in this way was about 65°C., the pieces being dried in from 24 to 36 hours. Although faster driers are used for some clays in practice, it was decided that if the clays can be worked and afterwards dried safely at the above temperature, that the object of the experiments had been attained.

The preheating causes marked changes in the character of the clay, the most important for practical purposes being the change from a tough sticky mass, having undue shrinkage and abnormal cracking in drying, to an open granular body which can be easily worked and rapidly dried.

The preheated clays require considerably less water for mixing than the raw clays, consequently the air shrinkage

in the clays thus treated is greatly reduced as shown in the following table.

No.	Average per cent air shrinkage.	
	Raw clay	Preheated clay.
1644	9·5	4·0
1755	7·0	8·0
1765.	8·7	5·0
1875	8·9	5·0
1600.	8·5	3·5
1796.	8·6	4·0

Another striking advantage gained in preheating is seen when burning the test pieces. Those clays which were subject to black coring and swelling were completely cured of this trouble by the preheating treatment. This is probably due to the change in texture which the clay undergoes when preheated, giving a more open body from which the gases evolved in burning can escape freely, and also to the driving off of some of the carbonaceous and sulphurous components.

The effects obtained by preheating to the above temperatures are not permanent.

The plasticity of the clays Nos. 1675 and 1800, apparently destroyed during the course of the experiments, was restored again by allowing those clays to remain in an excess of water for 24 hours. Sufficient water was then evaporated, so that the clay could be remoulded, and set to dry. No. 1675 would still stand fast drying, but No. 6 cracked both in the fast and slow drier

Again, when the cubes made from No. 6 were dried, reground, and wetted for the third time it was found that this clay had regained all its pristine plasticity and stickiness, and small bricklets then made from it cracked while air drying at room temperature quite as badly as the raw clay did.

ANALYSES OF CLAYS WHICH CRACKED IN DRYING

	No. 1765	No. 1796	Bentonite from Camrose.
Total silica (SiO_2)	74·25	65·23	69·14
Alumina (Al_2O_3)	14·29	18·60	14·50
Oxide of iron (Fe_2O_3)	2·89	2·97	2·56
Lime (CaO)	0·37	0·66	2·45
Magnesia (MgO)	Trace	0·64	1·14
Potash (K_2O)	2·52	2·40	0·20
Soda (Na_2O)	1·19	2·23	1·25
Loss on ignition	4·21	7·30	7·71
	99·72	100·03	98·95
Supplemental determinations.			
Organic carbon	not determined	1·44	not determined
Carbon dioxide (CO_2)	none.	0·48	0·52
Sulphur trioxide (SO_3)	none.	none.	1·70
Hydrous silica.	0·43	0·51	21·03
Sulphur	none.	none.	not determined.

In the table given above will be found analyses of several of the clays described in this chapter. They were made by G. E. F. Lundell.

The greater part of these clays is made up of quartz grains of varying degrees of fineness, as many clays are, and the chemical analysis furnished no clue to their erratic behaviour.

About 20 feet below the beds from which sample No. 1796 was taken a seam of about 2 feet in thickness of the clay known as *bentonite* occurs. This variety of clay is of yellow colour when fresh from the bank, but assumes a dirty white colour on exposure. It is fine in texture, exceedingly smooth, and forms a very soft soapy mass when mixed with an excess of water. It has an extraordinary capacity for absorbing moisture, being capable of taking up three times its weight in water.

The clay possesses marked detergent properties, and was used in the early days of the North West by Indians and Hudson's Bay Co. employees as a substitute for soap.

This material was rejected as unfit for any burned clay wares, but an attempt was made to dry some bricklets made from it, in a moist atmosphere. After three weeks of gradual

drying the bricklets showed abnormal cracking and very high shrinkage. Although none were observed on the outcrop, it is possible that some thin streaks of bentonite were included in the beds sampled for number 1800. Certain of the sand beds of the vicinity were found to possess plasticity, and some decidedly silty beds will crack in slow drying.

As a good deal of the material which composes these beds is derived from the erosion of the lower Cretaceous which contains bentonite beds it may be assumed that this material, being part of the product of erosion, was re-deposited and distributed through many of the later beds.

It occurred to the writer that some simple scheme of washing might be adopted to separate out the pasty constituent from these clays.

As an experiment one pound of ground shales from sample No. 1675 was well stirred up in about a gallon of water and allowed to settle for two hours, the water and suspended matter being then drawn off. This operation was repeated, and the residue allowed to dry. When the residue had dried, it was found to consist of a badly cracked yellow paste about half an inch in thickness, forming a crust on top of dark grey sand and silt. The yellow paste had all the appearance and characteristics of bentonite or soap clay.

The shale when dry was found to have lost 25 per cent of its weight, presumably all of it being pasty matter held in suspension and drawn off with the water.

The plasticity of the shale was much reduced by the washing, but it cracked almost as badly as ever in the 65° drier. It would dry intact though in room temperature.

That the presence of bentonite is a potent factor in producing air cracks was proved by the following experiment. Ten per cent of bentonite from Camrose was added to a coarsely ground paving brick shale from Elmira, N.Y. The cube made from this mixture cracked badly in the 65° drier. The Elmira shale will stand fast drying at 85° C.

Between bentonite as an extreme case and clay No. 1755 as a mild example we have clays containing varying amounts of gelatinous paste, which allows the water to escape

with difficulty from the body, and causes cracking while retarding drying

The chemical analysis of bentonite (see table) showed that it possessed a large amount of hydrous silica, which probably causes that sticky type of plasticity and the trouble in drying.

Preheating has the effect of driving out the water from the hydrous silica, and causing the caking together of the dehydrated particles, which gives the granular texture seen in the clays thus treated

Clay No. 1765 was washed in a similar way to No. 1675, but lost 75 per cent of its weight and the residue cracked in drying.

The chemical analysis made of it shows only a small amount of hydrous silica, but this clay, notwithstanding the low amount of that ingredient possesses all the pastiness of bentonite, and its tendency to crack is almost as pronounced.

A large percentage of this clay is in a very finely divided state and much of it may be colloidal matter, perhaps organic colloids are also present Then in this case preheating to sufficient temperatures has the effect of driving the water from the infinitesimal pore spaces between the minute grains, and the chemically combined water from the colloids. The minute particles when deprived of their water envelope appear to adhere in sufficient numbers to form sizable grains.

The subsequent safe drying after preheating seems to depend on the fact that the water with which the clay was tempered escapes by evaporation in the driers before it has time to permeate the microscopic pores again and hydrate the colloid or siliceous content.

Clays which retain or regain their plasticity after the expulsion of chemically combined water have been recorded at various times.

H. E. Kramm[1] found that test pieces made from mixtures of kaolin and gypsum, kept for 8 hours at a temperature of 790°C. slaked down in water, and had lost little or none of their original plasticity

[1]Trans. Am. Cer. Soc. Vol. XIII, p. 698.

Most of the clays can be made workable by the preheating process if commercial conditions allow of its use. This process involves the use of a suitable type of rotary kiln, a cheap fuel to supply the high temperatures at which these clays must be treated, a proper superintendence in controlling the process, and the cost of extra labour. The samples on which the experiments were made have been selected from localities in which either coal, lignite, or natural gas is abundant.

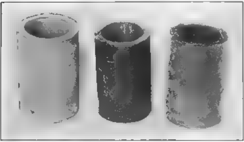
Clay No. 1644 undergoes a slight preheating through a rotary drier in the brickworks at Estevan. This is done primarily to prepare the clay for dry pressing by getting rid of the superfluous moisture which it contains in the bank, but the treatment was also found to stop much of the fire checking to which the raw clay was liable. The losses from fire checking are still great, but a higher degree of heat treatment would probably do away with it entirely.

It is doubtful if the kind of apparatus in use at Estevan would give a sufficiently high temperature to drive off combined water and render the clay fit for wet-moulded processes.

PLATE XXXVII

Cubes of clay showing the cracking which occurred in air drying
Preheating prevented this

PLATE XXXVIII



Salt glazed pipe made of clays from Western Provinces

CHAPTER VIII.

Special Tests.

Sewer-pipe Tests.

In order to ascertain the value of the western shales for the manufacture of sewer-pipe, samples were selected for special tests of those shales or clays which seemed to be of promise for pipe manufacture. These were moulded up to a very plastic mass and then pressed out through an annular die, giving a pipe whose outside diameter was 3 inches, and internal diameter 2.5 inches (Plate XXXVIII). Only those clays were used which flowed smoothly through the die, and these were cut up into 6 inch lengths.

After moulding, the pipes were dried and burned to cone 010, after which they were placed in the kiln of a sewer-pipe works, firing to cone 4.

It was to be expected that all of the samples tested might not yield the best results, as some would no doubt give better glazes when burned at a slightly different cone.

The clays used, together with the results obtained, were as follows:—

No. 1747.—Mixture of two parts Pierre shale from La-Rivière, and one part Niobrara shale from Leary, Man. This took a bright salt glaze, but not an exceptionally smooth one. This was undoubtedly due to the fact that the mixture was not ground fine enough, and that cone 4 is a trifle too high for these clays.

No. 1754.—Fireproofing clay from Coleridge, Alta. The salt glaze on this was fair, but the clay is hardly fire-resisting enough for successful salt glazing, even if its other physical properties were favourable to its use in sewer-pipe manufacture.

No. 1765.—Shale from Tofield, Alta., used in the proportions of 75 per cent raw clay and 25 per cent calcined clay, plus

2 per cent salt to prevent cracking in air drying This at cone 4 was much overfired, and we doubt if it would stand the heat required for salt glazing. It softened so at cone 4, that it was not stiff enough to hold its shape.

No. 1762.—Upper 7 feet of shale from south bank of Lobstick river near Entwistle, Alta.

The salt glaze on this was poor, and the clay itself is hardly refractory enough for making sewer-pipe.

Nos. 1805, 1806, and 1807 Mixture of equal parts of these three clays, from the Dirt hills, Sask.

This mixture gave excellent results at cone 4. The pipe was straight nicely vitrified, and the glaze smooth.

The mixture should undoubtedly make a good sewer-pipe. The unglazed pieces showed some soluble salts, but not enough to interfere with the salt glaze

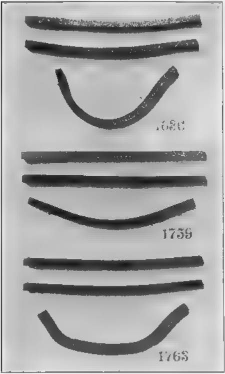
No. 1817.—Mixture of two parts of top shale, and 1 part under clay from Walton's mine Minto, N B.

This took a good salt glaze, although cone 4 seemed a little too high, and better results would no doubt be obtained at cone 3. Care should be taken to grind this shale fine.

No. 1824.—Shale overlying sandstone, at Stonehaven, N.B. Like the preceding this developed a good salt glaze at cone 4, but was a trifle overfired Cone 3 would be a better burning temperature for it. The clay should also be finely ground

Roofing Tile Tests

A clay in order to be useful for roofing tile should conform to certain requirements. These might be enumerated as follows (1) suitable plasticity, (2) moderate shrinkage, (3) sufficient strength, (4) wide vitrification range, (5) development of preferably a red colour in burning, which should be maintained without change over a range of several cones, (6) freedom from cracking and twisting in burning (7) slow and slight warpage if burned unsupported



Strips of burned clay used in the warpage test of roofing-tile clays

It may not be difficult to find a clay which shows the proper development of some of these properties, but materials which are eminently desirable in all respects are more difficult to obtain

In the manufacture of flat shingle tile and normal Spanish tile these slabs can be made by forcing a ribbon of clay through a slit like die, and then cutting the ribbon up into proper lengths.

More complicated shapes, such as interlocking tile, are made by forcing a bar of clay through the die of a stiff-mud machine, this bar being then cut up into slabs which are given the proper shape by re-pressing in a plastic or steel mould

One of the tests that may be applied to a roofing-tile clay in the laboratory, is the warpage test. This consists in moulding the clay or mixture of clays into thin strips 13 inches long, 1½ inches wide and ½ inch thick

These are carefully dried and then placed in the kiln resting on sharp edged fireclay supports, with a 10 inch span between the edges (Plate XL)

In our experiments these were burned at cones 010, 03, 05, and 1

We give below the names of the clays tested and the results obtained in each case

In the testing of roofing tiles it has been advocated by some that their transverse strength when air dried should be determined,[1] but as shown by others,[2] the transverse strength of an air-dried clay stands in direct relation to its tensile strength, consequently it seems sufficient in describing these tests to give the latter

CLAYS TESTED FOR ROOFING TILE.

Niobrara Shale from Leary, Man (1636) To this was added 25 per cent of grog, consisting of calcined shale, to improve its working qualities. The bars had an average air shrinkage of 5 5 per cent, and dried well without warping. The average tensile strength was 243 pounds per square inch.

[1]Orton and Worcester, Ohio Geol. Surv

[2]Ries and Allen Trans. Amer Ceram Soc., vol XII

At cone 08 the fire shrinkage was 5 1, the sag 0 35 inch, and absorption 12 2 per cent. At cone 05 the fire shrinkage was 6 per cent, the sag 0 58 inch, and absorption 10 2 per cent. At cone 1 the clay had sagged so as to give a deflection of 3½ inches, and is to be regarded as over fired. The clay is nearly steel hard at cone 08.

Clay from Dirt Hills, Alberta.—This a grey shale lying at base of section in hill No. 2 (1647).

The clay bars had an average air shrinkage of 7 per cent, and an average tensile strength of 334 pounds per square inch. It warped very slightly in drying.

At cone 08 the fire shrinkage was 1 per cent, the sag was 0 08 inch, and absorption, 15 5 per cent At cone 05 the fire shrinkage was 2 per cent, the sag 0 09 inch, and absorption 14 7 per cent At cone 1 the fire shrinkage was 8 per cent the sag 1 37 inch, and absorption 3 2 per cent. The clay burns light red up to cone 05, but deepens considerably at cone 1

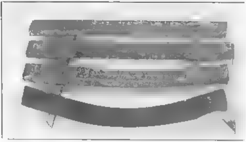
Shale from Kilgard. —(1738) —The strips of this shale dried perfectly and had an air shrinkage of 4 per cent. The average tensile strength was 114 pounds per square inch

At cone 08 the fire shrinkage was 0 per cent, the sag 0 08 inch, and absorption 22 6 per cent. At cone 05 the fire shrinkage was 1 per cent, the sag 0 09 inch, and absorption 17 3 per cent. At cone 1 the fire shrinkage was 6 5 per cent, the sag was 1 14 inch, and absorption, 7 3 per cent At cone 3 the fire shrinkage was 7 per cent, the sag 1 57 inch, and absorption 9 per cent. The colour after burning was a soft drab.

Shale over Coal at Minto, N B —(1817)—The shale dried well without warping. Its air shrinkage was 3 5 per cent, and tensile strength 68 pounds per square inch.

At cone 08 the fire shrinkage was 2 5 per cent, and sag, 0 28 inch, with an absorption of 9 per cent. At cone 05 the fire shrinkage was 4 5 per cent, and the sag 0 60 inch, with an absorption of 6 2 per cent.

The shale burns red, but the colour is somewhat dull



Showing the method used for setting bars of clay in kiln for warpage test

Surface Clay from Merritt, B C With 25 per cent sand added (1779A.) The mixture dried without warping and had an air shrinkage of 7 5 per cent, the tensile strength being 318 pounds per square inch.

At cone 08 the fire shrinkage was 9 5 per cent, the sag, zero, and absorption 13 2 per cent. At cone 05 the fire shrinkage was 0 5, and the sag still zero, with an absorption of 13 2.

The clay burned red but showed a tendency to scum, although this could be prevented.

Mixture of 3 Parts of Grey Sandy Clay from Camrose, Alta., and 1 Part Shale from Gwynne, Alta. -(1801A.) This clay showed a tendency to buckle in drying, and its air shrinkage was 8 per cent. The tensile strength of the mixture was 166 pounds per square inch.

At cone 08 the fire shrinkage was 0 per cent, the sag 0 13 inch and absorption 17 per cent. At cone 05, fire shrinkage still 0 per cent, sag 0 16 inch, and absorption 10 2 per cent.

The clay burns to a good red colour

Clay from Brickyard Site, Taber, Alta. -(1791)—This clay dried without appreciable warping and had an air shrinkage of 8 6 per cent. Its average tensile strength was 135 pounds per square inch.

At cone 08, the fire shrinkage was 2 per cent, the total sag 0 14 inch, and absorption 15 4 per cent At cone 05, the sag was 0 17 inch, and the absorption 14 4 per cent.

Lower Shale, South Side of Lobstick River, Near Entwistle (1763) This shale dried well without warping, and had an air shrinkage of 6 0 per cent. The average tensile strength was 114 pounds per square inch

At cone 08, the shale had a fire shrinkage of 2 5 per cent, a total sag of 0 18 inch, and an absorption of 13 6 per cent. At cone 05 the fire shrinkage was 3 per cent, the total sag 0 24 inch, and absorption 12 per cent. At cone 1, the fire shrinkage was slightly greater, being 5 per cent, the total sag 2 55 inch, and absorption 0 per cent.

The shale burns to a light red colour at the first two cones but is much darker at cone 1. It became steel hard at cone 05.

Sewer-pipe Shale East of Brickburn, Alta.—(1759).—This shale showed no distortion in drying, and had an air shrinkage of 6 per cent and the average tensile strength of 60 pounds per square inch.

At cone 08, it had a fire shrinkage of 1 per cent, the total sag 0·09 inch, and the absorption 12·3 per cent. At cone 05, its fire shrinkage was 1·5 per cent, total sag 0·16 inch, and absorption 11·7 per cent. At cone 1 the fire shrinkage was 6·5 per cent, with a total sag of 1·42 inch, and an absorption of 4·5 per cent.

The clay was steel hard at this last cone.

Shale from Valley of Bull's Head Creek, Alta.—(1757).—This warped slightly in drying and had an air shrinkage of 7 per cent. Its tensile strength was probably high.

At cone 08 the fire shrinkage amounted to 0·5 per cent, with a total sag of 0·12 inch, and an absorption of 10 per cent. At cone 05 the fire shrinkage was 0·5 per cent, the maximum sag, 0·18 inch, and the absorption 9 per cent. Its absorption at cone 1 was 2 per cent.

The clay burns red.

Fireproofing Clay, Coleridge, Alta.—(1754)—In drying this clay showed no tendency to warp. The air shrinkage was 4·6. The average tensile strength was 284 pounds per square inch.

At cone 08 the fire shrinkage was 0 per cent, the total sag 0·06 inch, and absorption 15·6 per cent. At cone 05 the fire shrinkage was still 0, the total sag 0·07 inch, and absorption 15·5 per cent. At cone 1 it sags still more, but the exact amount was not measured.

Surface Clay from Hazel Brae, Clayburn, B.C.—(1741.)—This clay dried well without warping, and had an air shrinkage of 6 per cent. The average tensile strength was probably good, but was not tested.

At cone 08 the fire shrinkage was 1 per cent, the sag 0.08 inch, and absorption 16 per cent. At cone 05, the fire shrinkage was 1 per cent, the sag 0.13 inch, and absorption 16.4 per cent. At cone 1 the clay was past vitrification, and had sagged badly.

The clay burns to a good red colour at the first two cones.

For convenience of comparison these properties are given in tabulated form in the following table.

TABLE I

Summary of Roofing Tile Tests.

				Cone 08.			Cone 05.			Cone 1.			Cone 3.			
Laboratory No.	Per cent water required	Tensile strength pounds per square inch.	Per cent air shrinkage	Per cent fire shrinkage	Sag in inches	Per cent absorption.	Per cent fire shrinkage	Sag in inches	Per cent absorption	Per cent fire shrinkage.	Sag in inches.	Per cent absorption	Per cent fire shrinkage.	Sag in inches.	Per cent absorption.	
1636	32	243	5.5	5	0.35	12.2	6	0.58	10.2		3½					red
1647	30	334	7	1	0.06	15.5	2	0.09	14.7	8	1.37	3.2				red
1738	18	114	4	0	0.08	22	1	0.09	17.3	6.5	1.14	7.3	7	1.57	8	drab
1817		68	3.5	2.5	0.28	9	4.5	0.6	6.2							red
1779A		3.6	7.5	0.5	0	13.2	0.5	0	13.2							red
1801A	24	166	8	0	0.13	17	0	0.16	10.2							red
1791	26	135	8.6	2	0.14	15.4	5.3	0.17	14.4							red
1763	22	114	6	2.5	0.18	13.6	3	0.24	12	5	2.55	0				red
1759	18	60	6	1	0.09	12.3	1.5	0.16	11.7	6.5	1.42	4.5				red
1757	21	—	7	3.5	0.12	10	0.5	0.18	9			2				red
1754	20	284	4.6	0	0.06	15.6	0	0.07	15.6							red
1741	30		6	1	0.08	16	1	0.13	16.4							red

TABLE II.

SUMMARY OF PHYSICAL TESTS.

Laboratory No	Locality	Per cent water required	Tensile strength lbs. per sq. in	Per cent air shrinkage	Cone 010 Per cent fire shrinkage	Cone 010 Per cent absorption	Cone 05 Per cent fire shrinkage	Cone 05 Per cent absorption	Cone 03 Per cent fire shrinkage	Cone 03 Per cent absorption	Cone 1 Per cent fire shrinkage	Cone 1 Per cent absorption	Cone 3 Per cent fire shrinkage	Cone 3 Per cent absorption	Cone 5 Per cent fire shrinkage	Cone 5 Per cent absorption	Cone 9 Per cent fire shrinkage	Cone 9 Per cent absorption	Cone of fusion	Colour	Remarks.
1745	Upper Pierre shale, LaRivière, Man.	33		4.8	2.3	27.7	5.4	21.0	6.0	20.4	6.0	19.4			6.6	16.8	8.0	13.4		Red	Not plastic.
1746	Lower	42	51	5.0	3.0	25.1	6.2	20.0	6.8	19.6			8.0	13.4	8.0	12.0				Red	
1747	Mixture of Pierre and Niobrara shale, Man.			5.0	1.6	23.8	5.0	14.8			6.0	12.3	6.5	10.4						Red	2 parts Pierre, 1 part Niobrara
1754	Fireproofing clay Coleridge, Alta	20	294	5.0	0	18.5	0	15.2	0	13.2	2.6	6.5	4.0	1.5					5	Red	
1755	Dry-press brick clay "	22		7.0	0	10.1	1.5	6.5	1.7	5.5	3.3	2.3							3	Red	Cracks while drying
1756	Light grey shale } Bullshead creek,			6.8	0	11.1	0.3	9.1	2.7	3.3									7	Red	" " "
1757	Yellow shale } south of	31		8.0	0.7	10.8	2.0	4.8	3.6	2.4									3	Red	" " "
1758	Soft yellow shale } Coleridge. Alta	20	234	7.0	0	9.6	0.7	9.0	1.7	6.3	3.0	4.2							3	Red	
1759	Dark grey shale 5 miles west of Calgary. Alta	18	60	6.0	0	13.2	0.7	11.0	3.0	[illegible]	3.4	6.7	3.6	4.5	4.0	4.5		V		Red	
1760	" " " Mitford, Alta.	17	203	5.0	1.0	11.1	2.0	10.8	3.6	[illegible]	5.0	3.1							3	Red	
1761	Grey shale. Entwistle. Alta	24		[illegible]	0	18.0	1.0	11.2	2.5	10.3	6.4	3.5		V					5	Red	
1762	Upper shale, " "	24	225	6.0	0	14.5	1.7	9.9	4.0	6.7	4.3	5.0	7.3	0					7	Red	
1763	Lower shale, " "	22	114	5.7	2.0	12.0	4.0	0.4	7.0	2.7	7.3	0							3	Red	
1764	Surface clay, Acme Brick Co. Edmonton. Alta.			7.0	0.4	22.0	0.8	19.4	1.3	11.7			10.0	0					5	Red	
1765	Dark shale under coal, Tofield. Alta																		13		
1766	Black shale, Blairmore Alta.						2.5	7.5			2.5	4.4							9	Red	Not plastic dry pressed only
1767	Grey " Frank, Alta.						3.5	5.6	2.5	5.2									2	Red	Not plastic, dry pressed only
1768	" " Coleman, Alta			4.0	s.s.	13.6	0.4	12.0	0.4	7.6									2		Low plasticity
1769	Surface clay Golden B C	32	60	4.5	s.s.	42.6	s.s.	42.6	s.s.	45.2									2	Buff	
1771	Grey calcareous shale. Morrissey, B.C							22.9											4	Buff	Not plastic, dry pressed only
1772	Bluish shale. Strathcona, Alta.	26	316	10.0	0.6	12.5	1.6	11.0	2.3	10.6	6.8	0.8							3	Red	
1773	White sandy clay Cypress hills, Sask.	20		4.0							1.0	11.0					4.0	4.2	25	Grey	
1774	Shale over coal. Merritt, B.C.	22		5.0	2.4	2.3	4.3	7.9	5.7	6.4	0.0	2.6	5.0	2.6	6.3	2.4			20	Grey	
1775	" under " Merritt, B.C	36		8.0	0.3	16.5	5.0	6.2	7.0	4.3	3.3	1.6							12	Red	Cracks while drying.
1776	White clay, Quichena B.C.	45		12.6											6.7	5.9			15	Pink	
1779	Surface clay, Nicola valley, B.C	29	412	10.0	0	15.2	4.5	13.0	8.0	2.2									1	Red	
1780	Hard grey shale, Wellington B.C			5.0	1.0	10.5	1.8	9.5	3.6	8.7									3	Red	Very low plasticity.
1782	" " " B.C			4.0	s.s.	17.7	s.s.	17.9	5.0	2.9									1	Red	" "
1783	" " " B.C					10.0										9.5	s.s.	10.6	20	Grey	Not plastic, dry pressed only.
1784	" " " Canal de Haro, B.C	14		4.0	0	12.7	2.7	7.0	4.5	2.7									1	Red	" "
1785	" " Nanaimo, B.C						2.0	3.2	2.0	2.0									1	Red	" " dry pressed only
1786	" " " Extension, B.C.			3.0	1.0	13.8	2.0	10.4			3.6	2.3	4.6	3.0	5.0	1.8				Red	
1787	" " " Descanso, B.C			4.0	0	14.6	4.0	7.3	8.0	1.0		V							3	Red	
1788	Shale parting in coal Clayburn, B C	16		3.5											5.0	8.0	5.7	7.1	33	Cream	
1789	" under coal, Clayburn. B C.	15	65	3.0							1.3	9.3	2.0	9.7	2.0	10.0	3.0	8.5	27	Cream	
1790	Dark shale under lignite, near Camrose, Alta	25		5.6	3.4	10.7	6.4	6.9	9.6	1.6									3	Red	Cracks while drying
1791	Shale from brickyard site. Taber, Alta.	26	135	8.0	1.0	13.6	6.8	8.1	6.0	5.2									2	Red	
1792	" under coal Taber Alta	27		8.0	1.7	10.9	3.4	5.0											1	Red	
1793	" " " Rock Springs mine, Taber, Alta	22	154	8.0	1.0	6.7	3.3	6.3											3	Red	Cracks while drying
1794	" over " " " " "	22	324	8.0	0	18.1	3.2	9.8	6.0	2.7									2	Red	
1795	Grey sandy clay, Camrose Alta	25	144	6.0	0	15.8	0	15.2	0.6	13.4									2	Red	
1796	Soft yellow shales, near Camrose. Alta	29	120	8.8	1.0	14.6	2.6	0.6	5.8	3.6									3	Red	Cracks while drying.
1797	Shale between lignite, near Camrose, Alta.	28		7.0	0.6	16.2	7.3	4.9	8.3	0.8									1	Red	" " "
1799	Shale over lignite. Dinant, Alta	26		7.5	1.0	12.5	5.0	8.7	7.5	4.0									2	Red	" " "
1800	Soft olive shale near Gwynne. Alta.	25	232	8.5	1.4	10.6	2.0	9.3											2	Red	" " "
1801	Soft yellowish shale. near Gwynne, Alta	24	140	8.0	1.3	14.5	2.0	11.9	5.3	3.7									9	Red	" " "
1802	Surface clay at brickyard Saskatoon Sask.	25		8.0	1.0	15.7	1.7	14.3			4.7	1.9							3	Red	
1803	Niobrara shale, Lost Mountain lake, Sask.	27	600	12.0	2.4	7.3	4.3	3.5	7.0	0									5	Red	
1805	Grey shale over lignite, Dirt hills, Sask	32	383	9.0	1.3	19.2	8.6	1.4											1	Red	
1807	Light grey and yellow clay Dirt hills, Sask	27	456	9.0	1.7	11.6	4.0	7.0	4.3	7.5	4.3	6.8	5.7	4.9	6.3	2.2	5.7	0	23	Buff	
1808	White sandy clay Dirt hills, Sask.	25	123	5.0							3.0	9.3			3.0	9.1	3.5	6.4	31	White	
1809	Yellow surface clay, Regina Sask	27		3.6	0.4	15.2	1.0	12.4	2.7	5.9									1	Red	
1810	Niobrara shale, Tantallon. Sask	23		8.2	0	14.1	6.3	1.3												Red	

Abbreviations: s.s.=slight swelling. V=vitrified.

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